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The Influence of Initial Cow Weight on Progeny Performance and TDN Efficiency in Production of Slaughter Cattle

James Burkett Neel
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by James Burkett Neel entitled "The Influence of Initial Cow Weight on Progeny Performance and TDN Efficiency in Production of Slaughter Cattle." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

Sam L. Hansard, Major Professor

We have read this dissertation and recommend its acceptance:

Will T. Butts, Jr., James A. Corrick, Jr., Karl M. Barth, J.K. Bletner, Robert S. Dotson, Luther H. Keller

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

February 15, 1973

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Vice Chancellor for
Graduate Studies and Research

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THE INFLUENCE OF INITIAL COW WEIGHT ON PROGENY PERFORMANCE AND TDN EFFICIENCY IN PRODUCTION OF SLAUGHTER CATTLE

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

James Burkett Neel

March 1973

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ABSTRACT

Data utilized in this study were from records (collected over a two-year period) of 45 Angus cow-calf pairs in which both the individual TDN consumption of the cows over a twelve-month period and the individual TDN consumption of the calves from birth to slaughter (excluding TDN provided by milk) were recorded. The objectives of this study were to determine total digestible nutrient (TDN) consumed by cows of various sizes and weights, to determine the TDN intake of both cow and calf per unit weight of slaughter calves which varied in growth potential, to establish weights at which maximum TDN utilization occurred, and to establish relationships among characteristics of cows and calves, and overall TDN efficiency and TDN efficiencies for various periods.

Cows were selected at weaning, confined to individual pens and individually fed to the following weaning. Cows selected ranged in weight from 835 lb. to 1,195 lb. In addition to initial weight, skeletal measurements and subcutaneous fat deposition between the twelfth and thirteenth ribs were recorded at the initiation of each trial. Milk production of the cows were made at 28-day intervals.

Data collected on the calves were weights recorded at birth and at 28-day intervals during the preweaning period and at 14-day intervals during the post-weaning period. Ultrasonic measurements of subcutaneous fat thickness were recorded at weaning and at each weighing

during the post-weaning period. Skeletal body measurements of the calves were recorded at approximately 120-days of age, at weaning, and at slaughter.

Cows were fed a grass silage ration of 20 percent TDN supplemented with dehydrated alfalfa pellets to insure adequate energy and dry matter intake. The cows were fed to maintain condition and weight during the nonlactation or wintering period and were fed *ad libitum* during the lactation period in an attempt to simulate pasture condition.

During lactation, the calves ran with the cows and were provided a creep feed of alfalfa pellets in an attempt to simulate feed intake under pasture conditions. Following weaning, the calves were individually fed a 60 percent TDN ration to slaughter.

The total amount of cumulative TDN consumed by each cow-calf pair at a given progeny age was determined by combining the TDN consumed by the cow during both the nonlactation and lactation periods and adding the amount of TDN consumed by the calf from birth to slaughter in addition to the TDN provided by the milk.

Efficiency of TDN utilization for a cow-calf pair was calculated as the ratio of cumulative TDN to live weight at that particular age. The point at which the ratio of cumulative TDN intake to live calf weight was minimum was referred to as the point of maximum TDN utilization.

Cows utilized in this study averaged 1,020 lb. (S.D. = 99.0 lb.) in initial weight. Weight and linear measurements of the cows were significantly ($P<.05$) positively related. However, small, nonsignificant ($P>.05$) relationships were observed between MPPA, weight and initial cow body measurements.

Annual TDN intake of the cows averaged 4,338 (S.D. = $\pm$459 lb.). Initial cow weight exhibited a significant ($P<.01$) linear effect on annual TDN intake in that annual TDN intake increased 314 lb. as initial cow weight increased 100 lb. Neither MPPA nor average daily milk production was significantly ($P<.05$) related to annual TDN intake.

Daily milk production was positively, but nonsignificantly ($P>.05$), influenced by initial cow weight and linear dimensions. Sex of calf did not influence milk production.

Initial cow weight did not have a significant ($P<.05$) effect on either calf birth weight or weaning weight. However, the trend was for heavier cows to produce heavier calves at both birth and weaning. Birth weight increased 3.3 lb. and weaning weight 6.9 lb. for each 100 lb. increase in cow weight. Hook width was the only cow trait to exhibit a significant ($P<.05$) positive relationship to calf birth weight. Initial fat thickness of the cows exhibited a significant ($P<.05$) influence on weaning weight. Heifers were lighter at weaning than either steer or bull calves. Calves heavier at weaning were also deeper and longer bodied and taller at both the withers and hooks.

Initial cow weight had a significant ($P<.01$) linear effect on calf weight at maximum TDN utilization. Calf weight increased 33.5 lb. for each 100 lb. increase in cow weight. Total milk production of the cows and calf age exhibited a significant ($P<.05$) influence on calf weight at point of maximum TDN utilization, and post-weaning TDN consumption of the calves exhibited a highly significant ($P<.01$) influence. Calves heavier at maximum TDN utilization were also deeper and longer bodied and taller.

Cumulative TDN intake averaged 5,049 lb. (S.D. = $\pm$504 lb.) at weaning and 7,422 lb. (S.D. = $\pm$815 lb.) at maximum TDN utilization and was significantly ($P<.01$) influenced by initial cow weight. An increase of 100 lb. in initial cow weight resulted in 289 lb. and 464 lb. increase in cumulative TDN at weaning and maximum TDN utilization, respectively. Eighty-six percent of the cumulative TDN intake at weaning and 58.0 percent at maximum TDN utilization was composed of the annual TDN intake of the cow. Calves which were heavier, older and larger in body dimensions required increased amounts of cumulative TDN to reach maximum TDN utilization. It was concluded that both cumulative TDN intake at weaning and point of maximum TDN utilization were a function of size of both the dam and progeny.

Calves produced by heavier and fatter cows and calves which were heavier, taller and longer bodied required a longer period of time to reach maximum TDN utilization. Calf age at maximum TDN utilization increased 15 days for each 100 lb. increase in initial cow weight.

TDN efficiency was determined as the ratio of cumulative TDN intake to live calf weight. TDN efficiency at weaning averaged 9.60 (S.D. = $\pm$1.12) and was significantly ($P<.01$) influenced by initial cow weight. TDN efficiency increased 0.4 for each 100 lb. increase in initial cow weight.

Although weight, cumulative TDN intake, and age of calves at point of maximum TDN utilization differed, TDN efficiency averaged 8.49, exhibited very little variation (S.D. = ± 0.6) and was not significantly ($P < .05$) influenced by either initial cow weight or any calf trait. However, when evaluated either prior to or past maximum TDN utilization, both the values and variation in TDN efficiency increased.

These results indicated that TDN efficiency at weaning was primarily a function of size of both the dam and progeny while at point of maximum TDN utilization, size of the dam and progeny exhibited very little influence on TDN efficiency.

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CHAPTER I

INTRODUCTION

The determination of optimum cow size for maximum productive efficiency has long been of concern to beef cattle producers. In recent years, emphasis in beef cattle improvement programs has been directed toward increasing weight for age in beef cattle. Heavier weights at young ages, in both males and females, have been accepted as desirable goals by the beef industry. In general, these selection criteria favor larger animals and have resulted in increased mature size of both males and females.

Available research results indicate that feed requirements of beef cattle are positively related to body weight. Therefore, with larger animals, feed requirements for maintenance of the calves as well as the breeding herd are increased. Since heavier cows cost more to maintain in the breeding herd, the question arises whether larger cows are capable of producing calves of sufficient extra economic value to offset increased maintenance costs and whether "smaller" cows can produce calves that can be efficiently utilized by the industry. Further information is needed concerning the relationship between cow size, progeny performance and efficiency of production.

In evaluation of productive efficiency, a study of the relationship between total weight produced and total feed consumed at various stages of production is necessary. Total feed consumed should include that consumed by the dam and that consumed by the growing animal. When only the feed consumed by the growing animal is considered, feed intake either up to a constant weight or over a constant period of time might be expected to be more efficient in faster growing animals. However, from the standpoint of total productive efficiency, feed consumption of the dam also must be considered.

The ratio of total feed intake of growing animal only to live weight produced should be at a maximum at birth and decline thereafter, ultimately attaining a minimum level at some future weight. Theoretically, this weight, from a feed efficiency standpoint, should be an ideal slaughter weight. However, this might not be the most profitable sale weight from an economic standpoint.

Determination of these points of maximum productive efficiency could be of importance in developing selection criteria which favor individuals that tend to maximize efficiency, taking into consideration the complete cycle of production.

The objectives of the study herein reported were as follows:

1. To determine annual total digestible nutrient (TDN) consumed by Angus cows varying in weight and past progeny performance.

2. To determine the TDN intake per unit of calf produced up to slaughter for calves varying in growth profile.

3. To establish optimum slaughter weights of calves under objective 2 from the standpoint of TDN efficiency.

4. To estimate relationships among characteristics of cows and calves, overall feed efficiency and feed efficiencies for various periods.

CHAPTER II

REVIEW OF LITERATURE

This review has been organized into two sections: (1) factors which contribute to the feed requirements of cows of various sizes and (2) effects of cow size on productivity as measured by progeny performance.

I. FACTORS INFLUENCING FEED REQUIREMENTS

Annual feed cost of the brood cow is probably the single most important item in commercial cow-calf operation. Annual cow feed costs have been estimated to be 55 to 59 percent of the total annual cost of producing a feeder calf (Lindholm and Stonaker, 1957; Petty, Boykin and Eddleman, 1965; Prater, 1970).

Factors, such as body weight, degree of condition, body dimensions and production, have been found to influence feed requirements of mature beef cows. These factors will be given consideration in the review.

Weight

The National Research Council's (N.R.C., 1970) current recommended feed requirements for maintenance of mature beef cows were based on the function of body weight to the 0.75 power. These feed requirement recommendations were based on the work of Garrett, Meyer and Lofgreen (1959).

In a study with identical twin calves, Winchester and Hendricks (1953) found that maintenance requirements varied with weight to the 0.66 power. However, other workers reported that feed requirements of mature beef cows were linearly related to body weight. Ewing et al. (1968) reported that the energy requirement for wintering mature pregnant beef cows could be estimated from the following formulas:

Daily Digestible Energy (DE)(Mcal.) = 5.669 + 0.00831W(lb.)

Daily Total Digestible Nutrient (TDN)(lb.) = 2.771 + 0.00379W(lb.)

In an earlier report, Ewing et al. (1967) reported that the annual TDN required to maintain a mature cow, exclusive of milk production, increased at a rate of 7 percent for each 100 lb. increase in weight.

In a study of "large" and "compact" cows, Knox (1957) measured forage intake by the amount of lignin voided in the feces and observed a linear relationship between feed intake and body size. However, Stonaker, Ingalls and Wheeler (1952) reported that feed consumption of mature cows increased with body weight, but there was no significant differences in amount of feed consumed per 100 lb. of body weight. They concluded that about the same weight of similar aged breeding cattle could be maintained on a given land area and that this would be independent of their individual size characteristics.

Rate of maturity has been reported to influence energy requirements of beef cows. Brown and Brown (1971) in a study of simulated data reported that earlier maturing cows cost more to maintain at all ages up to five years. However, the cost to reach a given weight was greater for the slower maturing cows at all weights. Annual costs of maintenance would be approximately the same, but development costs varied because of different rates of maturity.

Condition

Several studies presented conflicting results pertaining to the relationship of condition and feed intake. McCandlish and Gaessler (1920) observed that "fleshy" cows required 7.39 lb. TDN per day to maintain 1,000 lb. of live weight while "thin" cows required only 5.43 lb. TDN per day. Eckles, Gullickson and Neal (1927) reported similar results in that dairy calves in normal condition required 5.43 therms per day per 1,000 lb. for maintenance whereas calves that were fat required 6.79 therms per day per 1,000 lb. maintained. Rebhan and Donker (1960) used three sets of monozygous dairy cows to study the effect of condition on energy requirements for maintenance and found a positive relationship between condition and feed requirements.

In contrast to these reports, Trowbridge, Moulton and Haigh (1915) concluded that condition has very little effect on maintenance energy requirements. Klosterman, Sanford and Parker (1968) also reported contrasting results to the positive relationship between condition and feed requirements in that there was a tendency for cows with a high degree of condition, indicated by weight to height ratio, to gain weight while cows in a thin condition lost weight when fed based on metabolic size. This might be explained in that since the amount of feed fed was determined by the function of weight to the

0.75 power, the fatter, heavier cows received a greater daily allotment of feed than the thinner, lighter cows.

Other researchers, Kress, Hauser and Chapman (1969), have reported that the ratio of weight to height is an acceptable indicator of condition with fat animals having greater weight per unit of height. Reports of Lambourne and Reardon (1963) and Graham (1967) with sheep supported the findings of Klosterman *et al*. (1968) in that the maintenance requirements of sheep were negatively related to condition. Per unit of weight, "thin" sheep were found to have a higher maintenance requirement than "fat" ones.

Body Measurements

Body measurements of beef cows have been used in an effort to account for more of the total variation in daily feed requirements. Smithson (1968) reported that weight alone accounted for 27.7 percent of the variation in daily annual digestible energy (DE) requirements. Addition of body length and heart girth separately to a regression model containing weight accounted for 44.8 and 42.9 percent of the daily DE requirements, respectively. However, consideration of weight, heart girth and body length together resulted in explanation of 55.2 percent of the variation in daily DE requirements. Melton, Cartwright and Kruse (1967) reported that a positive relationship existed between feed intake and cubic dimensions from the product of measurements of chest depth, width at hooks and length from a point between the first

Nevertheless, cow size has long been defined merely as weight. However, weight might not be a satisfactory estimate of size because of variations in condition, shape and contents of the digestive tract. Even so, weight remains the most widely used and accepted measure of size. This might be attributed to the ease with which weight can be obtained and understood.

Numerous studies have been made concerning the relationship between cow size, calf weight, milk production and efficiency of production. These factors will be discussed in the following review.

Relationship between Cow Weight and Progeny Performance

Numerous studies have indicated that calf birth weight tends to increase as weight of the dam increases (Woodward, Clark and Cummings, 1942; O'Mary, Brown and Ensminger, 1959; Vaccaro and Dillard, 1966; Klosterman, Cahill and Parker, 1968). Vaccaro and Dillard (1966) reported that calf birth weight increased 2.5 lb. for each 100 lb. increase in dam weight. Correlations of 0.23, 0.49 and 0.21 between previous fall weights of the dam and birth weight of the calf have been reported by Knapp, Lambert and Black (1940), Knapp *et al*. (1942), and Dawson, Phillips and Black (1947), respectively.

Several studies have indicated a positive linear relationship between cow weight and calf weaning weight. Gregory *et al*. (1950) reported a correlation between cow weight and calf weaning weight of 0.20. Marlowe and Stewart (1955) found that cow weight accounted for 12 percent of the total variation in calf weaning weight. O'Mary *et al*. (1959) found a somewhat higher significant correlation of 0.51

increased more slowly for Angus but remained approximately the same for Herefords. Tanner et al. (1965) also noted a curvilinear relationship in data collected from a group of Hereford cows. In the weight range of 600 to 900 lb., an additional 16 lb. of weaned calf was realized with each 100 lb. increase in cow weight while in the weight range from 900 to 1,500 lb., the increase was much lower. Fitzhugh, Cartwright and Temple (1967) reported similar results from data collected on 5,117 cow-calf pairs from 10 state and federal experiment station herds through the S-10 Beef Cattle Breeding Project.

Several other studies have shown that cow weight was not strongly related to calf weight. Vaccaro and Dillard (1960) observed very little relationship between dam weight 90 days prior to calving and calf weaning weight. Hawkins et al. (1965) observed that heavier cows prior to calving produced lighter calves at weaning. Meiske, Enfield and Harvey (1964) reported that dam weight had very little relationship to either birth or weaning weight of calves. These results agree with those observed by Neel (1966) in which previous fall weight of the dam was correlated 0.18 and 0.00 with progeny birth and weaning weight, respectively. These data tend to suggest that cow weight might not be a significant factor of productivity.

Data reviewed have generally indicated that heavier cows tend to produce heavier calves. The question arises whether the additional calf weight is sufficient to compensate for added costs of maintaining a larger cow. Petty et al. (1965) indicated that increases of 16 to 33 lb. are required to offset costs associated with 100 lb. increase in cow weight. Tanner *et al*. (1965) and Ewing (1967) reported that 17 to 19 lb. and 33 lb., respectively, would be required to offset the additional costs associated with 100 lb. increase in cow weight. Tanner *et al*. (1965) assumed a calf crop percentage of 85 percent and a market price of $25.00 per hundred weight in making this prediction.

Relationship between Cow Body Dimensions and Progeny Performance

Several workers have attempted to relate cow body dimensions to calf performance. O'Mary *et al*. (1959) reported positive, but nonsignificant, coefficients of correlations between height at withers, length (point of shoulder to pins), depth of body and adjusted 180-day calf weaning weights of 0.25, 0.33 and 0.27, respectively. Tanner *et al*. (1965) reported coefficients of correlation between calf weaning weight and cow wither height of 0.50, 0.52 and 0.52 were observed between length (point of shoulder to pins), rump length and heart girth circumference and calf weaning weight. The workers further stated that 20 percent of the total variation in calf weaning weight could be accounted for by considering either wither height or length separately, and when these two variables were combined, 25 percent of the total variation in calf weaning weight could be explained compared to only 12 percent when weight alone was used. Wilson *et al*. (1969) also reported low relationship between cow dimensions and calf performance.

Relationship between Cow Weight and Milk Production

It is general knowledge of cow-calf producers and has been demonstrated through research that a positive relationship exists between milk production of the dams and weaning weight of their calves (Melton et al., 1967). Pope et al. (1963) observed correlations between average daily milk production and weaning weights to range from 0.60 to 0.70. These generally large positive correlations between dam milk production and calf weaning weight add importance to the following summary of reports concerning relationship between body size and milk production.

In almost all cases in which the phenotypic relationship between cow body weight and milk production have been calculated, correlations tend to be very low (Touchberry, 1951; Blackmore, McGilland and Lush, 1958; Gillooly et al., 1959). Coefficients of correlations ranged from -.36 to -.14 which indicated a negative effect of increased cow weight on milk production and that cow weight might not be an important factor in milk production.

Relationship between Cow Weight and Reproductive Performance

There are limited data relative to the reproductive performance of various weight cows. Data reported by Knox (1957) revealed that large cows (1,066 lb.) averaged weaning a 93.9 percent calf crop compared to 81.6 percent for small cows (934 lb.). As a consequence, large cows averaged producing 13 percent more pounds of calf per 1,000 lb. cow, produced 33 percent more total calf weight and experienced a longer productive life. Hawkins et al. (1965) reported contrasting results in that cows with the heaviest precalving and weaning weights produced a smaller number of calves at birth which weighed less at weaning than calves produced by cows which weighed less at respective weighings.

Conflicting observations have been reported concerning influence of cow weight on calving interval. Totusek *et al.* (1969) observed no differences for average calving interval for two groups of eight-year old cows which differed in weight by an average of 323 lb. Carpenter, Fitzhugh and Brown (1971) observed that calving interval increased as body weight increased, which might be interpreted as indicating that large cows produced fewer calves over a constant time interval than small cows.

Relationship between Cow Weight and Productive Efficiency

A brood cow's efficiency should be determined in relation to the amount of inputs required to yield a product. Melton (1968) reported that smaller cows required less TDN to produce a pound of calf weight than larger cows. Kress, Hauser and Chapman (1969) evaluated two ratios which reflected the amount of saleable product to total TDN consumption as measures of efficiency. When these efficiencies were correlated to cow size and production traits, it was observed that the estimates of efficiency were negatively related to cow weight at calving, positively related to cow height at withers and negatively related to the ratio of weight to height at withers. The authors concluded that fatter cows were less efficient producers of calves than thinner cows.

It has been observed by livestock producers and well-documented by research that a high relationship exists between rate of gain and feed efficiency measured either up to a constant weight or over a constant period of time (Woodward *et al*., 1942; Washburn *et al*., 1948; Willey *et al*., 1951). These results tend to favor large animals. However, there are data available which indicate that when animals are not fed either to a constant weight or over a constant time period but to a similar grade or body composition, there is little difference in feed efficiency. Guilbert and Gregory (1944) pointed out that comparison of beef animal's performance either up to a constant weight or over a constant time interval might result in biased estimates of feed utilization because of considerable variation in weight and body composition; hence, the authors proposed feeding cattle to a constant degree of fatness for a more efficient test of feed utilization. Stonaker, Hazaleus and Wheeler (1952) and Brungardt (1971) fed calves which varied greatly in size and growth rate to Choice grade and concluded that there was no difference in efficiency of gain although carcass weight varied. Joandet and Cartwright (1971), working with both actual and simulated data, indicated that there is a point in the life of a slaughter animal at which the cumulative amount of TDN required to produce a pound of live weight is minimal and that this would occur at different ages and weights. The weight at which the ratio of amount of cumulative TDN intake to calf weight was a minimal value was referred to as the optimal slaughter weight. Comparison of the performance of the animals at this point revealed that the amount of cumulative TDN intake/calf weight ratios were very similar although weight and age varied.

Productive efficiency, from the viewpoint of total input and output, can be illustrated to be a complex variable which includes the individual animal's performance as well as the relationship between characteristics of the dam and progeny.

CHAPTER III

EXPERIMENTAL PROCEDURE

Data for this study were obtained from records of 45 cow-calf pairs individually fed to measure total feed consumed by cows of various sizes and weights, to determine total digestible nutrient (TDN) requirements per unit of slaughter calves which varied in growth profile, to establish weights at which maximum TDN utilization occurred and to establish relationships among characteristics of cows and calves, and overall TDN efficiency and TDN efficiencies for various periods.

This study was a cooperative project between the University of Tennessee Agricultural Experiment Station--Department of Animal Science and the S-10 Southern Regional Beef Cattle Breeding Project. These data presented are from the first two years of a five-year study.

I. SELECTION OF EXPERIMENTAL ANIMALS

Twenty-four cows were selected, in the falls of 1969 and 1970, based on estimates of body composition and subjective evaluation. Reports of Zimmerman, Pope and Stephens (1958), Pinney *et al*. (1962), and Neel (1966) indicated that fall weights of cows were reliable measures of their mature weights.

An attempt was made to insure against producing correlations between size of the dam and performance of the offspring. This was accomplished by selecting cows with most probable performing ability

(MPPA), lifetime progeny weaning gains below 1.88 lb. and above 2.00 lb. per day and equally distributed across the weight range of the cows. MPPA is a calculation of estimates of an individual's most probable or real performing ability with respect to a trait (in this case, adjusted average daily gain) which can be observed at successive intervals during an animal's lifetime. Cows selected had produced at least three calves from which MPPA's for weaning average daily gain had been calculated.

An attempt was made to select cows between the ages of 5 to 10 years. Due to the selection procedures, sources of variation in size, such as age, condition, productivity and environment, were minimized. Variation in weight and productive ability of the cows selected are illustrated in Tables I and II, pages 18 and 19, respectively. As many cows as possible were carried over from the 1969 test to the 1970 study. Cows were removed from the test if considered to be open at the beginning of the 1970 trial.

II. PROCEDURE AND MANAGEMENT

At the initiation of each trial, the cows were randomly assigned to 6.5 ft. x 40 ft. individual feeding and loafing pens. The pens had concrete floors and were located partially under an open shed. Each pen had an automatic waterer, a large feed stall equipped with a gate at the rear for the cow and a small feed stall accessible only to the calf. The cows were maintained continuously in the individual pens for feeding purposes during both the nonlactation and lactation periods.

TABLE I

MEANS, STANDARD DEVIATIONS, AND RECORDED VALUES OF INITIAL TRAITS OF COWS USED IN 1969-70 TRIAL

Cow No.	Age (yr.)	Weight (lb.)	MPPA (lb./day)	Fat (mm.)	Condition Score
1325	5	1195	1.98	9	12
501	9	1180	1.87	12	12
273	7	1140	2.01	16	12
4491	9	1115	1.93	8	11
1205	5	1115	1.67	11	12
845	5	1115	1.63	11	12
713	7	1095	1.85	9	11
24	6	1070	2.01	9	11
314	6	1055	1.99	8	13
700	10	1030	2.05	18	13
115	5	1030	1.81	4	8
50	10	1020	1.98	6	9
2421	9	1015	1.94	13	9
933	7	1015	1.93	6	11
723	7	995	2.09	5	10
301	9	990	1.95	6	9
44	6	985	2.02	5	10
526	4	970	1.97	3	8
3901	9	970	1.99	10	10
25	5	920	1.67	10	10
871	9	920	1.83	9	8
193	7	890	1.83	7	7
305	5	875	1.90	9	6
$\bar{X}$	7.0	1030.6	1.90	8.9	10.3
S.D.	$\pm$1.8	$\pm$ 88.0	$\pm$0.12	$\pm$3.6	$\pm$ 1.7

TABLE II

MEANS, STANDARD DEVIATIONS, AND RECORDED VALUES OF INITIAL TRAITS OF COWS USED IN 1970-71 TRIAL

Cow No.	Age (yr.)	Weight (lb.)	MPPA (lb./day)	Fat (mm.)	Condition Score
1325	6	1195	1.98	9	12
501	10	1180	1.87	12	12
273	8	1140	2.01	16	12
1205	6	1115	1.67	11	11
845	6	1115	1.63	11	12
713	8	1095	1.85	9	12
206	5	1070	1.66	12	11
24	7	940	2.01	9	11
314	7	1055	1.99	8	13
700	11	1030	2.05	18	13
115	6	1030	1.81	4	8
241	10	1015	1.88	6	9
44	7	985	2.02	5	10
3251	10	975	1.69	8	9
324	7	970	1.76	3	8
1504	7	940	1.88	5	9
25	6	920	1.67	2	8
871	8	920	1.83	2	5
193	10	890	1.83	2	5
305	6	875	1.90	3	8
2305	6	825	1.90	3	8
137	4	810	1.81	5	9
$\bar{X}$	6.7	1010.0	1.85	8.4	10.0
S.D.	$\pm$1.9	$\pm$ 109.3	$\pm$0.13	$\pm$3.9	$\pm$ 1.9

The cows and cow-calf pairs were removed from the individual pens and placed in loafing areas at night for exercise and exposure to bulls during the breeding season.

Pregnant cows were removed from the pens approximately 7 days prior to parturition (determined by observed breeding dates and subjective evaluation) and placed in calving lots in which they remained with their calves until approximately 14 days post-partum.

III. FEEDING

During both the nonlactation and lactation periods, the cows were fed in an attempt to maintain condition and weights considered to be "normal" for cows in that particular stage of production. Data collected from other studies, weight records, ultrasonic measurements of fat tissue and subjective evaluations were used to measure the success of the feeding programs.

The cows were fed a sorghum-sudan grass silage (Sudex) ration during the nonlactation and lactation periods of the 1969-70 study. In addition to the full feed of silage, cows were fed dehydrated alfalfa pellets at the rate of 10 percent of silage intake during lactation for 70 days until the supply of Sudex was exhausted. The cows were then fed orchard grass silage until weaning.

During the nonlactation period of the 1970-71 trial, the cows were fed Sudex silage supplemented with alfalfa hay at 10 percent of silage intake throughout the remainder of the period and were again full-fed Sudex silage except during the last 85 days of the lactation period when orchard grass silage was fed. Both silage rations were supplemented with alfalfa pellets at the rate of 10 percent of silage fed.

As previously stated, an attempt was made to produce cow weights and weight changes typical of a normal production environment by *ad libitum* feeding during the lactation period. Under a normal production environment, mature cows lose weight following parturition and during early lactation and then return to their previous fall weights (Zimmerman *et al*., 1958; Pinney *et al*., 1962; Neel, 1966). However, these typical weight changes did not occur during the 1969-70 trial due to either stress created by the confinement or to low intake of the silage.

On the assumptions that the fall weights of the cows were their typical mature weights, that the cows carried over from the 1969-70 trial returned to their former fall weights in the fall of 1970, and that the weight loss was due to inadequate energy intake, the difference between weight of the cows at weaning of their calves in the fall of 1970 and 1971 was multiplied by 2.73 to obtain TDN equivalents of the weight loss to adjust the TDN intake to that required to return cows to their typical weights. This has been demonstrated by Knott, Hodgson and Ellington (1934) and Smithson (1968) to be an acceptable method for obtaining TDN requirements of weight loss.

The use of 2.73 as a TDN adjustment factor was justified by Knott *et al*. (1934), who reported that the energy value of a pound of gain in live weight would be 2692.3 calories, that the relative value of feed energy for maintenance, milk production and body increase would be 1.00, 0.985, and 0.761, respectively, and that 0.341 lb. of TDN would be required to produce 1 lb. of 4 percent milk with an energy value of 336 calories which would produce only 260 calories when used for increase in body weight. By assuming perfect conversion of the energy of the body weight into energy of milk, 1 lb. of body weight (2692.3 calories) would produce 8.01 lb. of 4 percent milk. Since it requires 0.341 lb. of TDN to produce 1 lb. of 4 percent milk, 1 lb. of body weight when converted to milk would replace 2.73 lb. of TDN in feed.

A creep feed of alfalfa pellets was provided the calves during preweaning in an attempt to approximate gain and condition of non-creep fed calves on pasture.

Following weaning, the calves were fed a growing-finishing ration *ad libitum* until slaughter. Composition of the ration is presented in Table III.

IV. BREEDING OF COWS

Cows utilized during the 1969-70 study were bred to 8 different bulls selected primarily on rate of gain to 15 months, distributed across all weight ranges and productive abilities.

The 1970-71 cows were mated to 3 bulls comparable in genetic size and growth potential to small, medium and large cows. Weight per

TABLE III

COMPOSITION[a] OF RATION FED CALVES DURING POST-WEANING FEEDING PHASE

Ingredient	Percent of Ration
Corn, No. 2 Yellow	59.0
Cottonseed Meal (41% C.P.)	10.0
Cane Molasses	5.0
Dehydrated Alfalfa Meal (17% C.P.)	3.0
Animal Fat	2.0
Corn Cobs	20.0
Ground Limestone	0.5
Salt	0.5

[a]In addition to the ingredients presented, 1.5 million International Units of Vitamin A per ton was added to the ration.

day of age at approximately 15 months of age and subjective evaluation of the bulls were utilized to estimate the bull's genetic size.

V. DESCRIPTION OF DATA

Data collected on the cows included weights taken at the initiation of each trial (beginning of nonlactation period), at monthly intervals throughout the production cycle and 2 days post-partum.

In addition to the weights, ultrasonic measurements of subcutaneous fat depth (FT) were made at each weighing. Fat depth was measured with a Bronson Model 12 Sonoray over the *longissimus dorsi* muscle between the twelfth and thirteenth ribs three-fourth the distance between the dorsal midline and distal edge of the *longissimus dorsi* muscle. This locus was determined by palpation.

The cows were scored for condition by a member of the Animal Science Department at the initiation of the nonlactation period and at weaning of calves.

Photographs of each cow were made in a specially designed grid chute at the beginning of each trial and at weaning of calves. Thirty-five mm. color slides were projected to "life size" on a screen with linear measurements being recorded directly from these projections. The following measurements were made for each cow:

1. Depth of body (DB) -- from the chest floor, posterior to the elbow, to the smallest distance to the top of the back.

2. Length of body (LB) -- from the point of shoulder to the center of the pin bone.

3. Height at withers (HW) -- from the base of the grid chute to the top of the withers.

4. Height at hooks (HH) -- from the base of the grid chute to the top of the back through the hook bone.

5. Length of rump (LR) -- from the center of the hook to the center of the pin.

These points were located by palpation prior to photographing and were identified by application of white paint.

In addition to the aforementioned photographic measurements, the following physical measurements were made utilizing a steel tape:

1. Hook width (HKW) -- the distance between the most prominent projections of the hooks.

2. Pin width (PW) -- the distance between the most prominent projections of the pins.

Means, standard deviations and recorded measurements are presented in Tables IV and V, pages 26 and 27, respectively.

Milk production of the cows was made at 28-day intervals by the calf-nursing method as described by Drewery et al. (1959). Calves were separated from their dams 12 hours prior to measurement. The following morning at 6:00, the calves were weighed before and after nursing. The difference in weight was considered to be the amount of milk consumed by the calf and hence the milk production of the cow. Following the second weighing, the calves remained separated from their dams until

TABLE IV

MEANS, STANDARD DEVIATIONS, RECORDED WEIGHTS AND LINEAR MEASUREMENTS OF COWS USED IN 1969-70 TRIAL

	Weight (lb.)	Body Depth (in.)	Body Length (in.)	Wither Height (in.)	Hook Height (in.)	Rump Length (in.)	Hook Width (in.)	Pin Width (in.)
	1195	27.2	56.5	47.0	47.6	15.7	21.5	11.0
	1180	27.2	55.2	46.2	46.2	13.6	21.5	11.2
	1140	26.9	51.6	45.6	46.2	16.2	19.0	10.0
	1115	24.4	51.3	44.8	46.2	15.7	20.0	10.5
	1115	27.2	53.0	44.6	45.6	15.5	20.0	10.5
	1115	27.4	54.3	46.2	46.3	16.0	22.0	12.0
	1095	27.4	55.7	47.0	46.7	13.6	21.0	11.0
	1070	27.2	53.2	46.8	46.7	15.8	19.5	11.0
	1055	25.3	50.5	44.6	44.6	15.7	19.0	10.5
	1030	26.1	51.6	43.7	43.7	13.6	19.0	11.0
	1030	24.4	51.1	43.5	44.3	16.0	18.0	10.5
	1020	25.3	54.3	44.0	45.4	14.4	18.0	10.0
	1015	26.1	52.9	45.1	44.6	13.6	21.0	10.5
	1015	26.6	52.7	44.8	45.6	15.5	21.5	10.5
	995	24.4	53.5	45.9	46.2	13.6	20.5	11.0
	990	25.6	53.8	45.6	47.0	16.0	21.5	9.5
	985	25.8	51.9	46.7	46.7	15.5	20.0	12.5
	970	24.7	51.6	45.6	45.2	16.6	20.0	12.0
	970	24.4	52.4	46.2	47.6	14.4	20.5	12.5
	920	23.6	48.9	42.9	43.7	12.8	18.0	10.0
	920	23.9	52.2	44.8	45.9	15.2	20.0	9.5
	890	24.4	51.6	46.2	46.2	14.9	19.5	10.5
	875	23.9	51.6	44.0	45.1	14.1	18.5	10.0
$\bar{X}$	1030.6	25.6	52.7	45.3	45.8	15.0	20.0	10.8
S.D.	$\pm$ 88.0	$\pm$1.3	$\pm$1.8	$\pm$1.2	$\pm$1.1	$\pm$1.1	$\pm$1.2	$\pm$0.8

TABLE V

MEANS, STANDARD DEVIATIONS, RECORDED WEIGHTS AND LINEAR MEASUREMENTS OF COWS USED IN 1970-71 TRIAL

	Weight (lb.)	Body Depth (in.)	Body Length (in.)	Wither Height (in.)	Hook Height (in.)	Rump Length (in.)	Hook Width (in.)	Pin Width (in.)
	1195	27.2	56.5	47.0	47.6	15.7	21.5	11.0
	1180	27.7	55.2	46.2	46.2	13.6	21.5	11.2
	1140	26.9	51.6	45.6	46.2	16.2	19.0	10.0
	1115	27.2	53.0	44.6	45.6	20.0	20.0	10.5
	1115	27.4	54.3	46.2	46.3	16.0	22.0	12.0
	1115	27.4	55.7	47.0	46.7	13.6	21.0	11.0
	1095	26.4	50.3	45.7	45.3	13.8	20.5	10.5
	1070	24.9	53.2	46.1	46.2	15.2	21.0	11.2
	1055	25.3	50.5	44.6	44.6	15.7	19.0	10.5
	1030	26.1	51.1	43.7	43.7	13.6	19.0	11.0
	1020	24.4	51.1	43.5	44.3	16.0	18.0	10.5
	1015	25.2	52.0	44.5	44.5	15.0	20.2	11.0
	985	25.8	51.9	46.7	46.7	15.5	20.0	12.5
	975	26.4	49.2	42.1	42.5	14.6	20.0	11.0
	970	25.9	51.6	44.9	44.9	15.4	20.5	11.0
	940	25.9	52.4	43.7	43.3	16.1	19.2	12.5
	920	23.6	48.9	42.9	43.7	12.8	18.0	10.0
	920	24.4	52.2	44.8	45.9	15.2	20.0	9.5
	890	23.9	51.6	46.2	46.2	14.9	19.5	10.5
	875	23.9	51.6	44.0	45.1	14.1	18.5	10.0
	825	26.0	50.8	45.3	45.3	15.0	21.0	12.0
	810	24.8	45.3	42.9	43.7	12.9	17.5	9.5
$\bar{X}$	1010.0	25.8	51.8	45.0	45.3	15.0	19.9	10.8
S.D.	$\pm$109.3	$\pm$1.3	$\pm$2.3	$\pm$1.4	$\pm$1.3	$\pm$1.1	$\pm$1.2	$\pm$0.9

6:00 p.m. at which time the above procedure was repeated. The sum of the morning and afternoon yields represented daily milk production of the dam. The reliability of this method has been demonstrated by Totusek and Arnett (1965) and Wistrand and Riggs (1966).

An accurate measurement of the feed intake of the cows was determined by weighing the quantity of feed fed and weighing back that not consumed from the previous feeding.

Data collected on the calves were weights recorded at birth and at 28-day intervals during the preweaning period and at 14-day intervals during the post-weaning period.

Ultrasonic measurements of subcutaneous fat thickness of each calf, as previously described, were made at weaning during the 1969-70 study, at approximately 180 days of age and at weaning during the 1970-71 study and at each weighing during the post-weaning or full-feed phase during both trials. The procedure followed in measuring the fat tissue depth of the calves was identical to that described for the cows.

The calves were scored for condition by a member of the Animal Science Department at weaning and prior to slaughter.

VI. DETERMINATION OF MAXIMUM TDN EFFICIENCY

Efficiency of TDN utilization for a given cow-calf pair was calculated as the ratio between the amount of cumulative TDN (annual TDN intake of cow plus TDN consumption of calf from birth to slaughter in addition to TDN from milk) intake up to a given age and progeny live weight at that particular age. This ratio was referred to as TDN efficiency, and it would probably present a more accurate measurement of the TDN efficiency of the entire production system (cow + calf) than would measurements over segments of the production cycle. When two or more situations are compared in which efficiency is used as a comparison, the smallest figure represents the highest efficiency of TDN utilization.

The total amount of cumulative TDN consumed by each cow-calf pair at a given progeny age was calculated from the following:

1. The amount of TDN consumed by the dam during the non-lactation period.

2. The amount of TDN consumed by the dam during the lactation period.

3. The amount of supplemental TDN consumed by the calf from birth to weaning.

4. The amount of TDN consumed by the calf from weaning to slaughter.

The calculated TDN efficiency values were plotted against age from weaning to slaughter. The point at which the minimum amount of cumulative TDN required to produce 1.0 lb. of live weight was a minimum was referred to as the point of maximum TDN utilization. The weight at which this occurred was also referred to as the "optimum slaughter weight." The calves were not slaughtered until it was evident that this point had been surpassed.

A second degree polynomial equation was fitted to the calculated TDN efficiency values which resulted in R^2 values which ranged from

0.95 to 0.98. Age at which the maximum TDN utilization occurred was determined by taking the first derivative of the equation and setting it equal to zero. By entering this age into the original equation, the value for maximum TDN efficiency was obtained. A schematic presentation of a TDN efficiency curve is presented in Figure 1.

VII. FEED ANALYSIS

Representative samples from feed sources were taken monthly. The samples were processed, ground through a Wiley mill and then proximate analysis was conducted according to A.O.A.C. (1965) methods. *In vitro* dry matter digestibility determinations were made with the method outlined by Tilley and Terry (1963) of the forage fed the first year. Digestible dry matter coefficients obtained from the *in vitro* determinations were used with the conversion factors outlined by Heaney and Pigden (1963) to estimate the percent TDN of the forages. The estimated TDN percentages were in close agreement with those reported by the N.R.C. (1970).

Estimated TDN content of the other feeds was calculated by the use of values published in N.R.C. (1970) with adjustments for dry matter content. Chemical composition and estimated TDN content of feeds are presented in Table VI, page 32.

VIII. STATISTICAL ANALYSIS

Weaning performance traits, weaning cumulative TDN and weaning TDN efficiency values were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

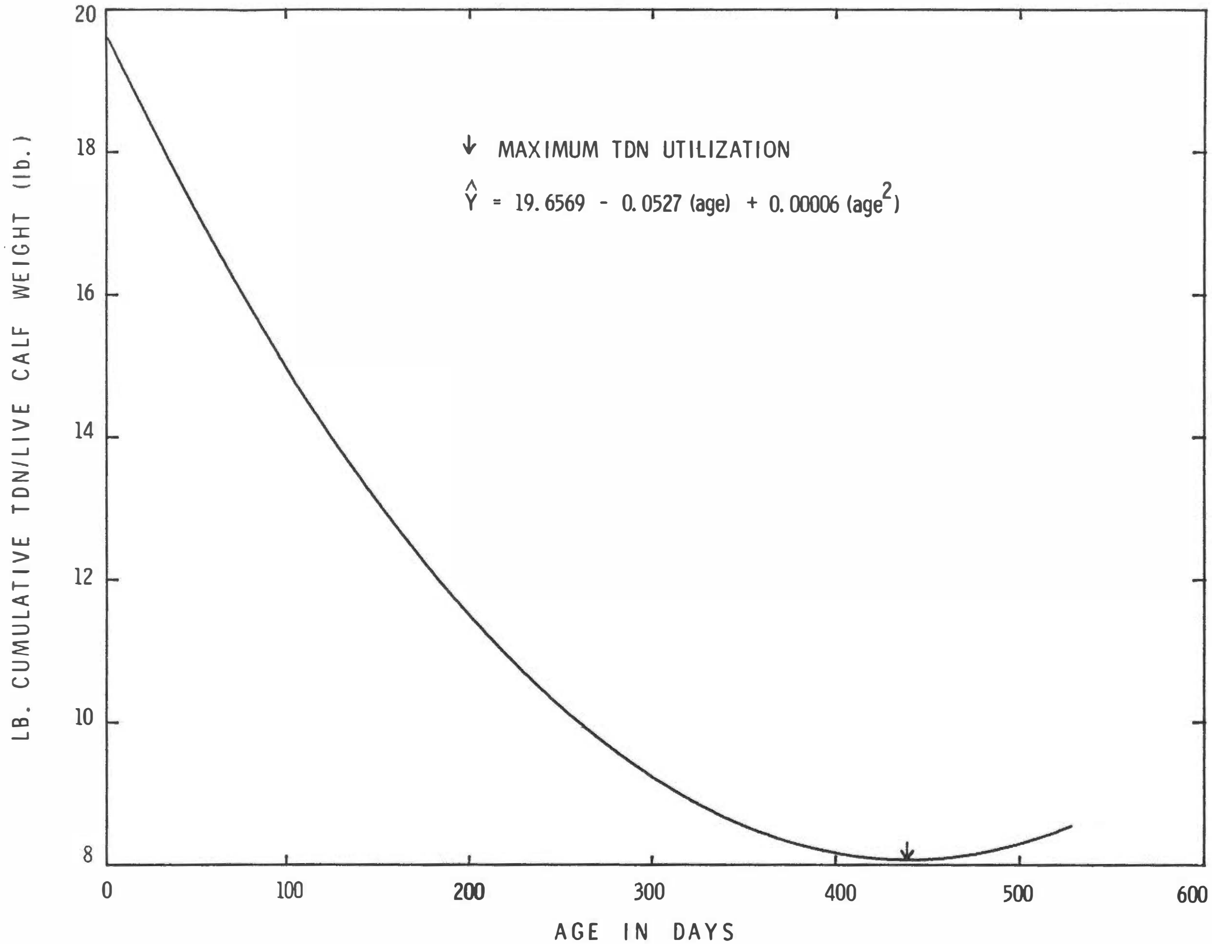

FIGURE 1

A HYPOTHETICAL PRESENTATION OF EFFICIENCY OF TDN UTILIZATION AT DIFFERENT AGES

TABLE VI

ESTIMATED TDN AND CHEMICAL COMPOSITION OF FEEDS, AVERAGE PROXIMATE ANALYSIS AND ESTIMATED TDN VALUES OF FEEDS

Feed	Estimated TDN (as fed)[a]	Dry Matter (as fed)[b]	Crude Protein (as fed)[c]
Sudex Silage	20.0%	33.5%	4.9%
Orchard Grass Silage	22.3%	33.8%	4.3%
Alfalfa Pellets	58.0%	93.5%	17.4%
Alfalfa Hay	50.0%	87.7%	14.9%
Mixed Concentrate	68.5%	85.7%	12.2%

[a]Determined by using N.R.C. (1970) values with adjustments for dry matter.

[b]Determined from proximate analysis.

[c]Determined by using proximate analysis with adjustments for dry matter.

Least square models were constructed using year, sex of calf and regression of the dependent variables on initial cow weight as a basic model (Harvey, 1960). Additional models were constructed by addition of other continuous variables to the basic model which were suspected to exert both biological and statistical influence upon the dependent variables in question.

Coefficients of determination (R^2) were computed for each model and were evaluated for their ability to increase the coefficient of determination of the dependent variable being considered. If the additional variable did not meet the above criteria, it was dropped from consideration.

CHAPTER IV

RESULTS AND DISCUSSION

Data utilized in this study were from records of 45 cow-calf pairs for which both the individual annual TDN consumption of the cows and the individual TDN consumption of the calves from birth to slaughter (excluding TDN provided by milk) were recorded.

The objectives of the study were as follows:

1. To determine the annual TDN consumed by Angus cows varying in weight and past progeny performance.

2. To determine total digestible nutrient (TDN) requirement per unit of calf produced up to slaughter for calves varying in growth profile.

3. To establish optimum slaughter weights of calves produced by cows of various mature sizes and productive abilities from the standpoint of total TDN efficiency.

4. To estimate relationships among characteristics of cows and calves, overall TDN efficiency and TDN efficiencies for various periods.

The results of this study will be presented in the following order: cow performance, progeny performance, and TDN efficiency at weaning and at maximum TDN utilization.

I. COW PERFORMANCE

Relationship among Cow Traits

Coefficients of correlations, presented in Table VII, among initial cow traits indicated that heavier cows were also larger in body measurements and that an increase in one linear measurement resulted in increased length in the others.

The small and nonsignificant ($P>.05$) relationship of productive ability (MPPA) to cow weight and linear measurements indicated that increased size (either weight or linear measurements) did not result in increased production potential.

Least square means and standard deviations of initial weight, productive ability (MPPA) and initial body measurements are presented in Table VIII, page 37.

Annual TDN Intake of the Cows

Individual TDN consumption of the cows was determined and reported on an annual basis (nonlactation plus lactation TDN intake). Least square model containing year, sex of calf and initial cow weight was used as independent variables to explain variation in annual TDN intake. Results of analysis of variance for this model are presented in Table IX, page 38, and least square constants from the model are presented in Table X, page 39.

Neither year nor sex of calf significantly ($P<.05$) influenced annual TDN intake of the cows. The nonsignificant ($P>.05$) effect of year might be explained by the adjustment of annual TDN intake to

TABLE VII

COEFFICIENTS OF CORRELATIONS AMONG INITIAL COW CHARACTERISTICS[a]

	2	3	4	5	6	7	8
Initial Weight (1)	0.057	0.428**	0.647**	0.740**	0.450**	0.463**	0.916**
MPPA (2)		- .002	0.155	- .036	0.266	- .043	- .043
FT (3)			0.123	0.382*	- .003	0.018	0.489**
LB (4)				0.594**	0.694**	0.700**	0.467**
DB (5)					0.486**	0.600**	0.700**
HTW (6)						0.691**	0.147
HKW (7)							0.261
WT/HTW (8)							

[a]Correlations were calculated from data in which the effects of year had been removed.

*P<.05.

**P<.01.

TABLE VIII

LEAST SQUARE MEANS AND STANDARD DEVIATIONS OF INITIAL COW CHARACTERISTICS[a]

	Mean	S. D.
Initial Weight (lb.)	1020.3	99.0
MPPA (lb./day)	1.88	0.13
Initial Fat (mm.)	8.6	3.8
Depth of Body (in.)	25.7	1.3
Length of Body (in.)	52.2	2.1
Height at Withers (in.)	45.1	1.3
Hook Width (in.)	19.9	1.2
Initial Weight/Height at Withers (lb./in.)	22.6	1.9

[a]Means were calculated from data in which the effects of year were removed.

TABLE IX

ANALYSIS OF VARIANCE FOR THE EFFECTS OF YEAR, SEX OF CALF AND REGRESSION ON INITIAL COW WEIGHT OF TOTAL ANNUAL TDN INTAKE AND AVERAGE DAILY MILK PRODUCTION

		Mean Square	
Source	DF	Total Annual TDN Intake	Average Daily Milk Production
Total	43		
Year	1	201054.38	11.95
Sex	2	12431.22	5.63
Regression	1	4085482.79**	17.71
Error	39	215996.40	5.37

**P<.01.

TABLE X

LEAST SQUARE MEANS, STANDARD DEVIATIONS, AND CONSTANTS FOR ANNUAL TDN INTAKE AND DAILY MILK PRODUCTION

	Number	Annual TDN (lb.)	Daily Milk Production (lb.)
Mean	45	4338.0	14.0
Standard Deviation		$\pm$ 459.0	$\pm$ 2.3
Year:			
1970	23	- 110.8	0.81
1971	22	110.8	- .81
Sex of Calf:			
Male	11	- 45.8	- .72
Female	20	5.4	0.24
Steer	14	40.4	0.48
Regression of Y on Initial Cow Weight		3.137	0.006

compensate for weight loss experienced by the cows during the 1970 trial.

Regression of annual TDN intake on initial cow weight resulted in a highly significant (P<.01) regression coefficient of 3.14 which indicated that for each 100 lb. increase in cow weight, annual TDN intake increased 314 lb. Regression of annual TDN intake on initial cow weight explained 32.3 percent of the variation in annual TDN intake and increased the total variation explained to 35.2 percent compared to only 3.8 percent explained by year and sex (Table XI). The amount of variation in annual TDN intake which was attributed to cow weight in this study was similar but slightly larger than the 28.0 percent reported by Smithson (1968). However, the cows in Smithson's (1968) study were fed to attain a predetermined weight and condition pattern.

Cow body dimensions, productive ability (MPPA) and milk production were used in an attempt to account for more of the total variation in annual TDN intake than that explained by the basic model. Depth of body was the only variable which contributed to a significant (P<.05) increase (9.8 percent) in amount of variation explained in annual TDN intake.

Coefficients of correlations, presented in Table XII, page 42, revealed large positive relationships between annual TDN intake, initial weight and linear measurements of the cows. The correlation coefficient between the ratio of initial cow weight to height at withers (WT/HTW) and total annual TDN intake (0.487) contrasted with

TABLE XI

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN ANNUAL TDN INTAKE[a]

		Regression Coefficients		
Equation Number	TDN Intercept (lb.)	Cow Weight (lb.)	Depth of Body (in.)	Variation Explained by Model (percent)
1	1145.86	3.13**		35.2
2	-1828.91	1.27	189.56*	44.0

[a]All models contained the discrete variables year and sex which accounted for 3.8 percent of the variation in total annual TDN intake.

*P<.05.

**P<.01.

TABLE XII

COEFFICIENTS OF CORRELATIONS BETWEEN COW CHARACTERISTICS, TDN INTAKE AND MILK PRODUCTION[a]

	Total Annual TDN	Daily Milk
Initial Weight	0.573**	0.276
MPPA	0.096	0.052
FT	0.175	- .102
LB	0.490**	0.057
DB	0.626**	0.069
HTW	0.430**	0.022
HKW	0.433**	0.156
WT/HTW	0.487**	0.263
Total Annual TDN		0.124

[a]Correlations were calculated from data in which the effects of year and sex were removed.

*$P<.05$.

**$P<.01$.

the negative results reported by Klosterman *et al*. (1968). However, in this study, the cows were fed *ad libitum* during lactation whereas in the study of Klosterman *et al*. (1968), the cows were fed based on metabolic size.

These results might be interpreted to indicate that annual TDN consumption of the cows was primarily a function of size, expressed either as weight or linear measurements, and was not influenced by either sex of calf or daily milk production.

Milk Production

Average daily milk production was not significantly ($P<.05$) affected by either year, sex of calf or regression on initial cow weight (Table IX, page 38). However, when considered at $P<.10$, regression of daily milk production on initial cow weight produced a regression coefficient of 0.006, which indicated that for each 100 lb. increase in initial cow weight daily milk production increased 0.6 lb.

The low relationship of cow weight to milk production was similar to reports of Touchberry (1951), Blackmore *et al*. (1958), Pope *et al*. (1963), and Melton *et al*. (1967), who reported that the relationship of cow weight was too low to be of importance.

Other variables thought to be biologically related to milk production were added to the basic model and tested for their ability to significantly increase the variation explained in daily milk production above that accounted for by the basic model. Weaning calf age was the only variable, when added to the basic model, which resulted in a significant increase (13.2 percent) in variation explained in average daily milk production (Table XIII).

The positive relationship between weaning age and average daily milk production contradicted the expected decrease in daily milk production as calf age increased. Several factors might have contributed to the positive relationship between weaning calf age and average daily milk production of the cows. Increased calf age would contribute to increased capacity of the calf's digestive system which would allow for increased milk consumption. In addition, the *ad libitum* feed intake of the cows provided a level of nutrient intake which might have contributed to maintenance of milk production throughout the lactation period. In addition, the close proximity of the cows and calves might have resulted in increased frequency of nursing which might have contributed to increased milk production.

The above discussion is also offered as explanation for the larger daily milk production (14.0 lb./day) for Angus cows than that reported by Gifford (1953), Drewry *et al*. (1959), and Melton *et al*. (1964), who reported average daily milk production for mature Angus cows ranged from 7.1 lb. to 10.1 lb. per day.

Coefficients of correlations between cow traits and milk production (Table XII, page 42) revealed nonsignificant ($P < .05$), but generally positive relationships with cow linear dimensions, initial weight, annual TDN intake, and milk production.

It might be concluded from these results that a low relationship existed between initial cow characteristics and daily milk production.

TABLE XIII

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN DAILY MILK PRODUCTION[a]

		Regression Coefficients		
Equation Number	Milk Intercept (lb.)	Cow Weight (lb.)	Calf Weaning Age (days)	Variation Explained by Model (percent)
1	7.85	0.006		14.6
2	- .88	0.005	0.045**	27.8

[a]All models contained the discrete variables year and sex which accounted for 7.5 percent of the variation in average daily milk production.

**$P < .01$.

II. CALF PERFORMANCE

Calf Birth Weight

Analysis of variance (Table XIV) indicated that calf birth weight was not significantly (P .05) influenced by either year, sex of calf or regression on initial cow weight. Least square means, standard deviations, constants, and regression coefficients are presented in Table XV, page 48. The low relationship of cow weight and calf birth weight is in agreement with results reported by Meiske et al. (1964), but is in contrast with reports of Knapp et al. (1942), Gregory et al. (1950), Vaccaro and Dillard (1966), and Klosterman et al. (1968), who observed that calf birth weight was positively influenced by dam weight.

Hook width was the only variable that produced a significant ($P<.05$) increase in variation explained in birth weight when added to the basic model (Table XVI, page 49). This positive relationship might be explained in that greater hook width would probably result in increased area for fetal growth and development.

Coefficients of correlations (Table XVII, page 50) revealed positive, nonsignificant ($P>.05$) relationship between birth weight, initial cow weight and initial cow measurements which indicated that larger cows (expressed as either weight or linear measurements) tended to produce heavier calves at birth. The coefficients between birth weight, initial cow weight, length of body and depth of body approached the level of significance (correlation coefficient of 0.30 was

TABLE XIV

ANALYSIS OF VARIANCE FOR THE EFFECTS OF YEAR, SEX OF CALF AND REGRESSION ON INITIAL COW WEIGHT OF BIRTH WEIGHT, WEANING WEIGHT, WEANING CUMULATIVE TDN INTAKE AND WEANING TDN EFFICIENCY[a]

		Mean Square			
Source	DF	Birth Weight (lb.)	Weaning Weight (lb.)	Cumulative TDN (lb.)	TDN Efficiency
Total	43				
Year	1	233.605	10033.146	2183.736	4.972*
Sex	2	63.854	10987.351**	56147.932	2.095
Regression	1	452.703	2002.982	3509817.705**	8.335*
Error	39	5154.588	3122.440	253897.669	50.029

[a]Weaning traits were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

*P<.05.

**P<.01.

TABLE XV

LEAST SQUARE CONSTANTS FOR BIRTH WEIGHT, WEANING WEIGHT, WEANING CUMULATIVE TDN AND WEANING TDN EFFICIENCY OF CALVES[a]

	Number	Birth Weight (lb.)	Weaning Weight (lb.)	Cumulative TDN (lb.)	TDN Efficiency
Mean	45	63.1	508.0	5049.0	9.60
Standard Deviation		$\pm$11.4	$\pm$ 55.9	$\pm$ 504.0	$\pm$1.12
Year:					
1970	23	3.6	23.4	- 10.9	- .52
1971	22	- 3.6	- 23.4	10.9	0.52
Sex of Calf:					
Male	11	- 1.5	30.4	38.4	- .40
Female	20	- 1.8	- 27.2	- 67.7	0.38
Steer	14	3.3	- 3.2	29.3	0.02
Regression of Y on Initial Cow Weight		0.033	0.069	2.894	0.004

[a]Weaning traits were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

TABLE XVI

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN CALF BIRTH WEIGHT[a]

		Regression Coefficients		
Equation Number	Birth Weight Intercept (lb.)	Cow Weight (lb.)	Hook Width (in.)	Variation Explained by Model (percent)
1	29.40	0.032		14.4
2	50.27	0.034	2.632*	20.3

[a]Models contained the discrete variables year and sex which accounted for 6.92 percent of the variation in birth weight.

*$P < .05$.

TABLE XVII

COEFFICIENTS OF CORRELATIONS BETWEEN INITIAL COW TRAITS AND CALF TRAITS AT BIRTH AND WEANING[ab]

Cow Traits	Calf Traits					
	Birth Weight	Weaning ADG	Weaning Weight	FT	Weaning Cumulative TDN	Weaning TDN Efficiency
Initial Weight	0.284	0.068	0.125	0.165	0.507**	0.378*
MPPA	- .109	0.145	0.098	0.069	0.134	0.019
FT	0.098	- .355*	- .241	0.194	0.105	0.305*
LB	0.294	0.045	0.263	0.004	0.497**	0.271
DB	0.292	0.188	0.099	0.214	0.571**	0.484**
HTW	0.149	0.119	0.109	0.037	0.308*	0.210
HKW	0.352	0.153	0.219	0.151	0.438**	0.255
WT/HTW	0.196	- .008	0.053	0.207	0.428**	0.369*
Annual TDN	0.397**	0.229	0.255	0.131	0.839**	0.600**
Daily Milk	0.026	0.256	0.265	0.460**	0.092	- .172

[a]Calf Weaning traits were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

[b]Correlations were calculated from data in which the effects of year and sex were removed.

*P<.05. **P<.01.

necessary to be significant, $P < .05$. The relationship between birth weight and initial cow traits might be improved with increased numbers.

Weaning Cumulative TDN Intake

Weaning cumulative TDN intake (composed of annual TDN intake of the cows plus supplemental TDN intake of the calves from birth to weaning) averaged 5,049 lb. (Table XV, page 48) and was not significantly ($P < .05$) influenced by either year or sex of calf (Table XIV, page 47). However, regression of weaning cumulative TDN intake on initial cow weight resulted in a significant ($P < .01$) regression coefficient of 2.89 and explained 25.30 percent of the variation in weaning cumulative TDN intake (Table XVIII).

Cow body depth was the only variable that produced a significant ($P < .01$) increase in variation explained in weaning cumulative TDN when added to the basic model (Table XVIII).

Coefficients of correlations among various cow traits and weaning cumulative TDN (Table XVII, page 50) indicated that as size of the cow increased (either by weight or linear measurements), the amount of TDN required to produce a weaned calf increased.

These results are similar to those for annual TDN intake of the cows which would be expected since average annual TDN intake of the cows composed 86.0 percent of the weaning cumulative TDN intake.

Calf Weaning Weight

Calf weaning weight was not significantly ($P < .05$) influenced by either year or regression on initial cow weight (Table XIV, page 47).

TABLE XVIII

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN CUMULATIVE TDN INTAKE AT WEANING[a b]

Equation Number	Cumulative TDN Intercept (lb.)	Regression Coefficients: Cow Weight (lb.)	Regression Coefficients: Depth of Body (in.)	Variation Explained by Model (percent)
1	2095.87	2.89**		26.8
2	- 894.48	1.05	189.34**	35.2

[a]Cumulative TDN intake was composed of annual TDN intake of the cow (nonlactation plus lactation) plus the supplemental TDN consumed by the calf preweaning. Cumulative TDN was adjusted to 270 days of age in 1970 and 253 days of age in 1971.

[b]Models contained the discrete variables year and sex which accounted for 1.51 percent of the variation in cumulative TDN intake.

**$P<.01$.

The low relationship between cow weight and calf weaning weight was contrary to reports of Knapp et al. (1942), Woodward and Black (1942), Gregory et al. (1950), O'Mary et al. (1959), Brinks et al. (1962), Neville (1962), and Vaccaro and Dillard (1966), but comparable to results reported by Hawkins et al. (1965), Neel (1966), Meiske et al. (1966), and Wilson et al. (1969).

Although the regression of calf weaning weight on initial cow weight did not result in a significant ($P < .05$) relationship, the regression coefficient (0.069) which resulted indicated that 6.9 lb. increase in calf weaning weight could be expected with 100 lb. increase in initial cow weight. These results are comparable to reports of Marchello et al. (1960), Sawyer et al. (1963), Tanner, Cooper and Kruse (1965) and Urick et al. (1971) who reported that calf weaning weight could be expected to increase 4.9 lb. to 14.6 lb. for each 100 lb. increase in cow weight. The wide range in expected increases in the literature might be confounded with maturity of the dams.

It can be observed from least square constants presented in Table XV, page 48, that bulls were heavier than steer or heifer calves at weaning. Bull calves might be expected to be heavier because of their aggressive nature which would contribute to increased milk and feed consumption. The endocrine makeup of the bull calves would also contribute to heavier weights and more efficient gains than either steer or heifer calves. The weight advantage of the bulls might be confounded with year effect in that bulls were only in the 1970 study and the year effects were approaching significance. The combined influence of year and sex accounted for 34.57 percent of the variation in calf weaning weight (Table XIX).

Addition of calf birth weight to the basic model accounted for 14.2 percent of the variation in weaning weight and increased the variation explained from 35.60 to 49.62. This indicated that heavier calves at birth maintained this advantage at weaning and that birth weight was more effective in explaining variation in weaning weight than maternal traits (Table XIX).

Initial fat thickness of the dam exhibited a negative influence on weaning weight (Table XIX) which indicated that fatter cows tended to wean lighter-weight calves. This conclusion might be corroborated by the negative relationship between milk production and initial fat thickness of the cows. The fatter cows might have lacked either the physiological ability or the genetic potential to convert feed to milk and as a consequence became fatter. These results are in agreement with those reported by Neel (1966) and Simpson _et al_. (1972), who reported a negative relationship between weaning weight and condition of the dam at the previous weaning.

Coefficients of correlation between maternal traits and calf weaning weight are presented in Table XVII, page 50. With the exception of initial fat thickness of the cow, all relationships were positive and nonsignificant ($P < .05$).

These results might be interpreted to indicate that maternal size characteristics had very little influence on weaning weight.

TABLE XIX

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN CALF WEANING WEIGHT[ab]

Equation Number	Weight Intercept (lb.)	Cow Weight (lb.)	Cow FT (mm.)	Calf Birth Weight (lb.)	Variation Explained by Model (percent)
1	437.51	0.069			35.60
2	370.00	- .006		2.296**	49.62
3	394.27	0.157	-5.326*		42.72
4	331.68	0.067	-5.151*	2.206**	56.60

[a]Calf weaning weight was adjusted to 270 days of weaning age in 1970 and 253 days of weaning age in 1971.

[b]Models contained the discrete variables year and sex which accounted for 34.57 percent of the variation in weaning weight.

*$P < .05$.

**$P < .01$.

TDN Efficiency at Weaning

TDN efficiency at weaning was determined as the ratio of weaning cumulative TDN to weaned calf weight. As previously stated, weaning cumulative TDN was composed of both the annual TDN intake of the dam and the supplemental TDN intake of the calf from birth to weaning.

Analysis of variance (Table XIV, page 47) indicated that weaning TDN efficiency was significantly ($P < .01$) influenced by year and regression on initial cow weight. The year influence might be explained in that weaning cumulative TDN intake between years was similar and the 1970 calves were heavier than the 1971 calves which resulted in smaller (more efficient) TDN efficiency values at weaning (Table XV, page 48).

Regression of TDN efficiency on initial cow weight produced a regression coefficient of 0.004 and an increase of 10.92 percent in the variation explained in weaning TDN efficiency above that attributed to year and sex (Table XX, Equation 1). The relationship of initial cow weight to weaning TDN efficiency is demonstrated in Figure 2, page 58. These data indicated that smaller (weight) cows were more efficient in TDN utilization than the larger (weight) cows.

Addition of cow body depth to the basic model increased the variation explained in TDN efficiency from 35.61 percent to 41.61 percent (Table XX, Equation 2). Regression of TDN efficiency on cow body depth produced a positive regression coefficient which indicated that on a weight constant basis, deeper bodied cows were less efficient in TDN utilization than shallow bodied cows. The strong relationship

TABLE XX

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN TDN EFFICIENCY AT WEANING[abc]

Equation Number	TDN Efficiency Intercept	Regression Coefficients: Cow Weight (lb.)	DB (in.)	Annual TDN (lb.)	Weaning Weight (lb.)	Total Milk (lb.)	Variation Explained by Model (percent)
1	5.50	0.004**					35.54
2	- .96	0.005	0.408*				41.61
3	6.64	0.005				- .006*	40.98
4	3.32	0.002	0.340			- .001*	45.66
5	4.11	0.001		0.001**			50.95
6	10.34	0.005			- .011**		54.57
7	3.81	0.001	0.415*		- .011**		61.89

[a]TDN efficiency = Cumulative TDN intake/weaning weight.

[b]Weaning TDN efficiency values, weaning weight and total milk were adjusted to 270 days of weaning age in 1970 and 253 days of weaning age in 1971.

[c]Models contained the discrete variables year and sex which accounted for 23.63 percent of the variation in weaning TDN efficiency.

*$P<.05$. **$P<.01$.

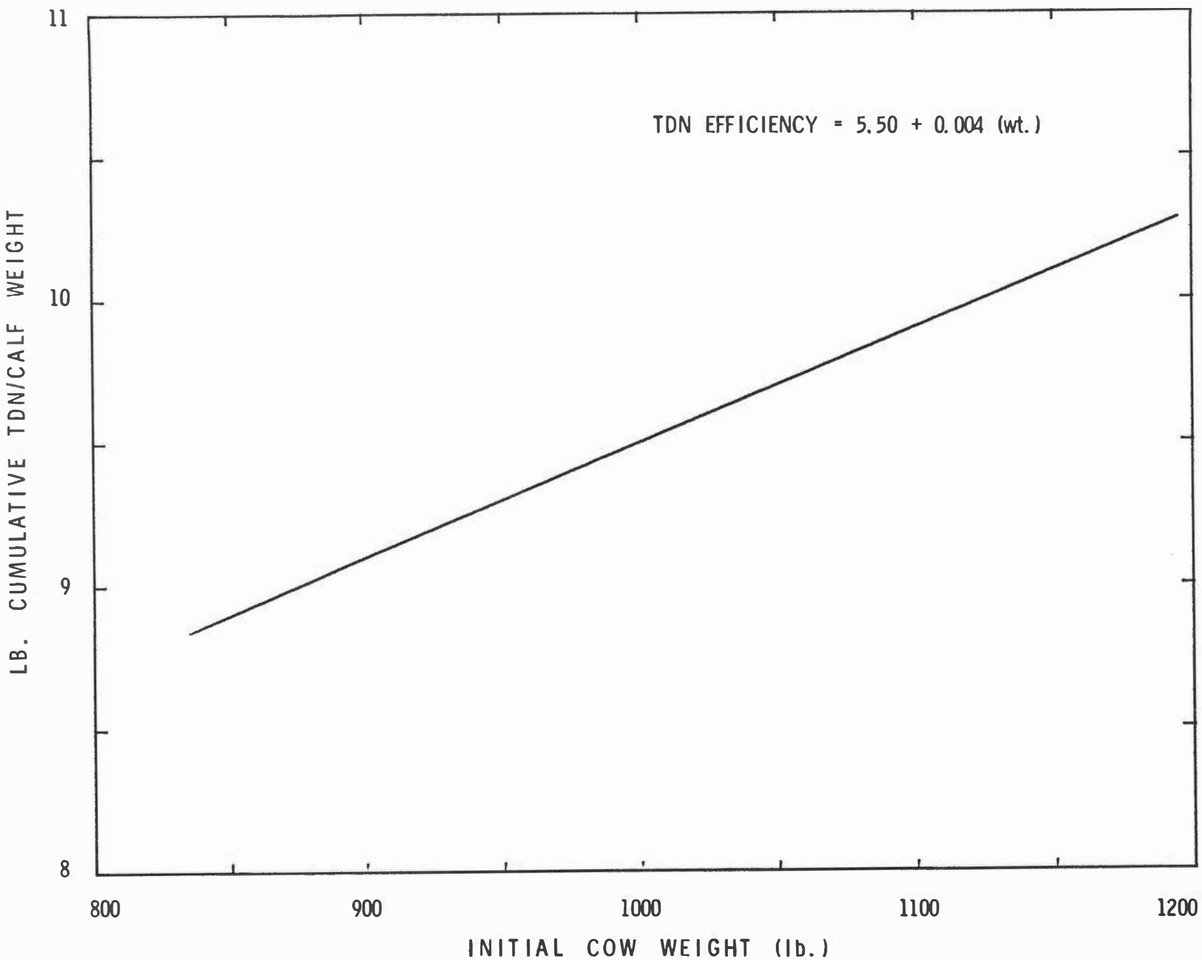

FIGURE 2

RELATIONSHIP BETWEEN INITIAL COW WEIGHT (Wt.) AND TDN EFFICIENCY AT WEANING of cow depth of body to weaning TDN efficiency might be explained by the earlier results in which cow depth of body was highly related to annual TDN intake.

The above conclusion is strengthened by the results of addition of annual TDN intake to the basic model in which 50.95 percent of the variation in weaning TDN efficiency was explained. Annual TDN alone accounted for 15.41 percent of the variation (Table XX, Equation 5, page 57). These results indicated that cows which consumed larger amounts of TDN were less efficient in production of weaned calves. In addition, this high relationship might be explained by the fact that annual TDN intake of the dam made up 85.92 percent of the weaning cumulative TDN intake which was the numerator in determination of the efficiency values.

Calf weaning weight explained the largest amount of variation in TDN efficiency. This should be expected since weaning weight was the denominator in calculating the TDN efficiency values. However, these results indicated that with initial cow weight held constant, heavier calves resulted in more efficient TDN utilization.

Cows that produced increased amounts of milk tended to be more efficient in the production of weaned calves as evidenced by the negative regression coefficient for total milk (Table XX, Equation 3 and 4, page 57) and the negative coefficient of correlation between average daily milk production and weaning TDN efficiency.

Coefficients of correlation between weaning TDN efficiency and initial cow traits were positive and are presented in Table XIV, page 47. These data indicated that as size (expressed as weight or linear dimensions) of the cow increased the TDN efficiency value increased, which might be interpreted to indicate that larger cows were not as efficient in TDN utilization as smaller cows.

The strong positive relationship between annual TDN intake of the cows and weaning TDN efficiency (Table XIV, page 47) added support to the earlier conclusion that cows which consumed large amounts of TDN were less efficient in TDN utilization.

Correlation among Calf Traits

Coefficients of correlation among weaning variables are presented in Table XXI. Birth weight was positively related to average daily gain, weaning weight and weaning cumulative TDN intake and slightly related to weaning TDN efficiency.

Weaning weight was positively related to weaning average daily gain, weaning cumulative TDN intake and negatively related to weaning TDN efficiency. These data add support to the earlier conclusion that heavier calves at weaning were produced more efficiently than lighter weight calves. The data also implied that heavier calves grew faster and required larger amounts of cumulative TDN in their production; however, due to the added weight advantage, they were more efficient at weaning.

Correlations presented in Table XXII, page 62, revealed strong positive relations between linear measurements, calf weight and average daily gain. Small but negative correlations were recorded between linear measurements and TDN efficiency values which indicated

TABLE XXI

COEFFICIENTS OF CORRELATIONS AMONG CALF PERFORMANCE[ab]

	2	3	4	5	6
Birth Weight (1)	0.385	0.479**	- .112	0.450**	0.020
Weaning ADG (2)		0.943**	0.292	0.457**	- .433**
Weaning Weight (3)			0.344*	0.483**	- .461**
Weaning FT (4)				0.193	- .137
Weaning Cumulative TDN (5)					0.548**
Weaning TDN Efficiency (6)					

[a]Weaning traits were adjusted to 270 days of weaning age in 1970 and 253 days of weaning age in 1971.

[b]Correlations were calculated from data in which the effects of year and sex were removed.

*P<.05.

**P<.01.

TABLE XXII

COEFFICIENTS OF CORRELATIONS AMONG CALF PERFORMANCE AND WEANING BODY DIMENSIONS[ab]

	Depth of Body	Length of Body	Height at Withers	Height at Hooks
Birth Weight	0.274	0.140	0.261	0.455**
Weaning ADG	0.574**	0.543**	0.429**	0.493**
Weaning Weight	0.583**	0.531**	0.434**	0.520**
Weaning FT	- .019	0.154	- .068	- .054
Weaning Cumulative TDN	0.458**	0.320*	0.356*	0.332*
Weaning TDN Efficiency	- .103	- .183	- .058	- .146
Depth of Body		0.721**	0.726**	0.223
Length of Body			0.805**	0.743**
Height at Withers				0.890**

[a]Weaning performance traits and body dimensions were adjusted to 270 days of weaning age in 1970 and 253 days of weaning age in 1971.

[b]Correlations were calculated from data in which the effects of year and sex were removed.

*$P < .05$.

**$P < .01$.

that larger (linear measurements) calves were more efficient in TDN utilization than small calves.

One of the basic questions concerning cow size is whether larger cows (weight) produce heavier calves at weaning and if so, is the increased weight advantage great enough to offset increased feed intake of the larger cows? This question might be answered from a TDN utilization standpoint by review of Figure 2, page 58. This figure demonstrated that heavier weight (initial weight) cows required more TDN to produce a pound of weaned calf than did smaller cows. If the larger (weight) cows were as efficient in TDN utilization, the line would have tended to become horizontal.

From a monetary standpoint, it is also questionable whether the heavier cows could compete with the smaller weight cows in weaned calf production. Results indicated that approximately 7 lb. increase in weaned calf weight could be expected with 100 lb. increase in cow weight compared to 313 lb. increase in annual TDN intake. It is doubtful that the increased weaning weight would offset the increased TDN costs under conditions of this study.

From these results, it might be concluded that smaller weight cows were more efficient in production of weaned calves. However, it should be realized that weaned calf production is only one phase of the production of a slaughter animal and a more effective evaluation of the entire production system should be realized at slaughter.

III. PERFORMANCE AT MAXIMUM TDN UTILIZATION

Weight at Maximum TDN Utilization

Calf weight at the point of maximum TDN utilization was significantly ($P<.05$) influenced by year, sex of calf and regression on initial cow weight (Table XXIII). It might be observed from least square constants presented in Table XXIV, page 66, that the 1970 calves were heavier than the ones produced in 1971. This difference might have been created by either the influence of the heavier weights of the bull calves which were only produced in 1970 or the fact that the cows utilized in the 1970 study were bred to eight different sires selected for weight; whereas in 1971, the cows were bred to bulls of similar genetic potential for size and growth. Heifer calves weighed less at the point of maximum TDN utilization than did either steers or bulls (Table XXIV, page 66), which would be expected since heifers tend to mature more rapidly and at lighter weights than do steers or bulls.

Regression of weight at point of maximum TDN utilization on initial cow weight indicated that for each 100 lb. increase in cow weight, calf weight would be expected to increase 33.5 lb. (Table XXV, page 67). This significant ($P<.01$) relationship of cow weight to calf weight at point of maximum TDN utilization was in contrast to the non-significant relationship at weaning. These conflicting results might be explained in that variation in size and maturity at weaning might not have been as great as at the point of maximum TDN utilization. Literature reviewed (Stonaker *et al.*, 1952; Fitzhugh and Taylor, 1971;

TABLE XXIII

ANALYSIS OF VARIANCE FOR THE EFFECTS OF YEAR, SEX OF CALF AND REGRESSION ON INITIAL COW WEIGHT UPON WEIGHT, CUMULATIVE TDN, TDN EFFICIENCY, AND AGE AT POINT OF MAXIMUM TDN UTILIZATION

		Mean Square			
Source	DF	Weight	Cumulative TDN	TDN Efficiency	Age
Total	43				
Year	1	95684.7**	2492722.5	0.4254	25193.33**
Sex	2	34296.2*	140524.4	1.7326*	1587.24
Regression of Y on Initial Cow Weight	1	47168.4*	9026824.9**	1.4063	9488.89**
Error	39	9150.1	663570.6	0.3589	993.11

*$P < .05$.

**$P < .01$.

TABLE XXIV

LEAST SQUARE MEANS, STANDARD DEVIATIONS, AND CONSTANTS FOR WEIGHT, CUMULATIVE TDN, TDN EFFICIENCY AND AGE OF CALVES AT POINT OF MAXIMUM TDN UTILIZATION

	Number	Weight (lb.)	Cumulative TDN (lb.)	TDN Efficiency	Age (days)
Mean	45	883.5	7421.7	8.48	428.1
Standard Deviation		± 95.6	± 814.6	±0.60	± 31.5
Year:					
1970	23	72.2	368.6	- .15	37.1
1971	22	- 72.2	- 368.6	0.15	- 37.1
Sex of Calf:					
Male	12	25.5	- 98.9	- .37	15.9
Female	19	- 53.2	- 67.1	0.35	- 7.6
Steer	14	27.7	165.9	0.02	- 8.3
Regression of Y on Initial Cow Weight		0.335	4.640	0.002	0.150

TABLE XXV

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN CALF WEIGHT AT POINT OF MAXIMUM TDN UTILIZATION[a]

		Regression Coefficients				
Equation Number	Weight Intercept (lb.)	Initial Cow Weight (lb.)	Total Milk[b] (lb.)	Calf Age at Maximum TDN Utilization (days)	Calf Post-Weaning TDN (lb.)	Variation Explained by Model (percent)
1	541.63	0.335**				48.61
2	444.98	0.251	0.048*			53.57
3	271.61	0.188		0.981*		53.99
4	471.12	0.127			0.119**	73.16
5	429.23	0.098	0.023		0.113**	74.19
6	680.93	0.196		- .832	0.151**	75.23
7	634.12	0.166	0.020	- .798	0.144**	76.09

[a]Calculated from least square equations of year, sex and regression of calf weight at maximum TDN utilization on initial cow weight, total milk, calf age at maximum TDN utilization and calf post-weaning TDN consumption. Year and sex were in all models and explained 42.0 percent of the variation in calf weight.

[b]Total milk was adjusted to 270 days of age in 1970 and 253 days of age in 1971.

*$P < .05$. $P < .01$.

Taylor and Fitzhugh, 1971) indicated that size difference between immature calves of similar age tended to be less than at mature size. Animals which were heavy at maturity tended to be less mature at similar ages compared to animals which matured to lighter weights at an earlier age. In addition, the adjustment of weaning weight to a constant age contributed to reduction in variation in weaning weight.

Addition of total milk to the basic model increased the variation explained in calf weight at maximum TDN utilization to 53.57 percent (Table XXV, Equation 2, page 67). This indicated that cows which produced increased amounts of milk tended to produce heavier calves at the point of maximum TDN utilization.

Calf age exhibited a positive influence on weight at point of maximum TDN utilization (Table XXV, Equation 3, page 67), which indicated that older calves tended to be heavier. This result might be explained in that the heavier calves were probably calves which matured slower to a heavier weight, thereby requiring longer time to reach maximum TDN utilization.

Addition of post-weaning TDN consumption to the basic model (Table XXV, Equation 4, page 67) increased the variation explained in calf weight at maximum TDN utilization to 73.16 percent and accounted for 24.55 percent of the variation above that explained by the basic model. Post-weaning TDN consumption accounted for more variation in calf weight than any of the other variables considered. The strong influence of post-weaning TDN consumption might be confounded with age and rate of maturity in that calves which took longer to reach maximum

TDN utilization would be the ones that consumed increased amounts of post-weaning TDN. Addition of post-weaning TDN consumption to the models which contained total milk (Table XXV, Equation 5, page 67) and calf age (Table XXV, Equation 6, page 67) significantly ($P < .01$) increased the variation explained in calf weight to 74.19 and 75.23 percent, respectively. When all the variables were entered in the model (Table XXV, Equation 7, page 67), 76.09 percent of the variation in weight was explained.

Weight of the calves at maximum TDN utilization was positively related to initial cow traits (Table XXVI). However, only the correlation coefficient with initial cow weight was of sufficient magnitude to be significant ($P < .05$).

Coefficients of correlations between calf weight and calf linear dimensions at point of maximum TDN utilization (Table XXVII, page 71) indicated that heavier calves were also deeper and longer bodied and taller at both the withers and hooks.

Coefficients of correlations presented in Table XXVI indicated that the heavier calves at point of maximum TDN utilization were the ones which made the greatest average daily gain, were the fattest, required larger amounts of cumulative TDN and were older at the point of maximum TDN utilization.

It might be concluded from these data that increased initial cow weight resulted in increased calf weight at the point of maximum TDN utilization. Calves from the larger cows probably possessed greater potential for growth and mature weight and thereby attained a larger weight at the point of maximum TDN utilization.

TABLE XXVI

COEFFICIENTS OF CORRELATIONS BETWEEN COW TRAITS ~~AND~~ CALF TRAITS, CUMULATIVE TDN, TDN EFFICIENCY AT POINT OF MAXIMUM TDN UTILIZATION[a]

Cow Traits	Calf Traits					
	Weight (lb.)	ADG (lb./day)	FT (mm.)	Cumulative TDN (lb.)	TDN Efficiency	Age (days)
Initial Weight	0.338*	0.002	0.386*	0.504**	0.299	0.439**
MPPA	0.061	- .012	- .048	0.059	- .049	0.015
FT	0.047	- .323*	0.148	0.207	0.321*	0.406**
LB	0.193	0.103	0.176	0.374*	0.232	0.109
DB	0.225	- .074	0.329*	0.500**	0.504**	0.429**
HTW	0.112	- .009	0.106	0.260	0.093	0.234
HKW	0.243	0.139	0.161	0.395**	0.220	0.218
WT/HTW	0.271	- .070	0.431**	0.447**	0.372*	0.420**
Annual TDN	0.516**	0.231	0.290	0.749**	0.356*	0.452**
Average Daily Milk	0.375*	0.200	0.226	0.248	- .100	0.226

[a]Correlations were calculated from data in which the effects of year and sex were removed.

*P<.05.

**P<.01.

TABLE XXVII

COEFFICIENTS OF CORRELATIONS AMONG VARIOUS CALT TRAITS AT WEANING (W) AND MAXIMUM TDN UTILIZATION (MTU)[a,b]

	Depth of Body (MTU)	Length of Body (MTU)	Height at Withers (MTU)	Height at Hooks (MTU)
Birth Weight	0.086	0.159	0.362*	0.213
ADG (W)	0.264	0.408**	0.267	0.406**
Weight (W)	0.302*	0.413**	0.298	0.403**
FT (W)	0.067	0.151	- .078	0.151
Cumulative TDN (W)	0.190	0.438**	0.386**	0.449**
TDN Efficiency (W)	- .091	0.044	0.090	0.071
Depth of Body (W)	0.220	0.530**	0.427**	0.467**
Length of Body (W)	0.047	0.629**	0.430**	0.517**
Height at Withers (W)	0.086	0.611**	0.620**	0.515**
Height at Hooks (W)	0.223	0.631**	0.656**	0.615**
Weight (MTU)	0.263	0.667**	0.518**	0.614**
ADG (MTU)	0.214	0.600**	0.382*	0.560**
FT (MTU)	0.246	0.173	0.294	0.219
Cumulative TDN (MTU)	0.218	0.589**	0.530**	0.626**
TDN Efficiency (MTU)	- .073	- .064	0.064	0.032
Age (MTU)	0.086	0.170	0.267	0.223
Depth of Body (MTU)		0.106	0.143	0.136
Length of Body (MTU)			0.629**	0.841**
Height at Withers (MTU)				0.723**

[a]Weaning performance traits and body dimensions were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

[b]Correlations were calculated from data in which the effects of year and sex were removed.

*$P < .05$.

**$P < .01$.

<u>Cumulative TDN Intake at the Point of Maximum TDN Utilization</u>

Initial cow weight was the only cow variable which significantly ($P < .01$) influenced cumulative TDN at the point of maximum TDN utilization (Table XXIII, page 65). Regression of cumulative TDN on initial cow weight indicated that for each 100 lb. increase in initial cow weight, cumulative TDN intake increased 464 lb. and accounted for 21.96 percent of the variation in cumulative TDN (Table XXVIII, Equation 1).

The influence of initial cow weight on cumulative TDN intake at the point of maximum TDN utilization was reduced compared to the influence at weaning. This reduction in influence might be attributed to the reduction in cumulative TDN intake composed of annual TDN intake of the cow. The explanation of reduced maternal influence on cumulative TDN was strengthened by the nonsignificant ($P > .05$) results obtained when cow body dimensions were added to the basic least square model.

Addition of annual TDN intake to the basic model increased the variation explained in cumulative TDN at maximum TDN utilization to 62.70 percent (Table XXVIII, Equation 2). These results emphasized the strong influence of the annual TDN intake of the cow on the TDN required in the production of a slaughter animal. These percentages would be expected to be greater with decreased calf crop percentages and TDN consumption of replacement animals.

Post-weaning TDN consumption of the calves added to the basic model increased the variation explained in cumulative TDN consumption at maximum TDN utilization to 76.14 percent (Table XXVIII, Equation 3).

TABLE XXVII

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN CUMULATIVE TDN AT MAXIMUM TDN UTILIZATION[a]

Equation Number	Cumulative TDN Intercept (lb.)	Regression Coefficients: Initial Cow Weight (lb.)	Annual TDN (lb.)	Calf Post-Weaning TDN Consumption (lb.)	Variation Explained by Model (percent)
1	2686.32	4.64**			35.44
2	1376.28	1.02	1.15**		62.70
3	1996.51	2.60**		1.17*	76.14

[a]Calculated from least square equations of year, sex and regression of cumulative TDN at maximum TDN utilization on initial cow weight, annual TDN and calf post-weaning TDN consumption. Year and sex were in all models and explained 13.8 percent of the variation in cumulative TDN.

*$P < .05$.

**$P < .01$.

This influence might be explained in that post-weaning TDN consumption of the calves made up 32.00 percent of cumulative TDN at maximum TDN utilization.

Coefficients of correlations presented in Table XXVI, page 70, indicated that initial weight and linear dimensions of the cows were positively related to cumulative TDN intake at maximum TDN utilization. This relationship might be explained in that the larger cows consumed increased amounts of annual TDN which made up a large percentage of the cumulative TDN intake at the point of maximum TDN utilization.

Calf weight, age, and body dimensions at the point of maximum TDN utilization were positively related to cumulative TDN intake (Tables XXVII and XXIX, pages 71 and 75, respectively). These results might be interpreted to indicate that calves larger in both weight and body dimensions required larger amounts of TDN to reach maximum TDN utilization than smaller cattle. These results might be explained in that larger calves were probably produced by larger cows and that calves which required a greater number of days to reach maximum TDN utilization would consume increased TDN. Both factors would have contributed to increased cumulative TDN intake.

It might be concluded from these data that the cumulative TDN at point of maximum TDN utilization was a function of size of both the dam and offspring.

TDN Efficiency at Maximum TDN Utilization

It has been a practice to evaluate efficiency of production from the standpoint of the cow-calf producer and feedlot operator. This

TABLE XXIX

COEFFICIENTS OF CORRELATIONS AMONG VARIOUS CALF TRAITS AT POINT OF MAXIMUM TDN UTILIZATION[a]

	2	3	4	5	6
Weight (1)	0.662**	0.440**	0.784**	- .131	0.422**
ADG (2)		0.034	0.402**	- .352*	- .324*
FT (3)			0.561**	0.267	0.630**
Cumulative TDN (4)				0.278	0.611**
TDN Efficiency (5)					0.324*
Age (6)					

[a]Correlations were calculated from data in which the effects of year and sex were removed.

*P<.05.

**P<.01.

might have contributed to the drawing of erroneous conclusions in favor of heavier calves. However, this study was concerned with the efficiency of utilization of that TDN consumed by the cow over a 12-month period plus TDN consumed by the calf (in addition to TDN from milk) from birth to slaughter (Figure 3).

TDN efficiency declined post-weaning, reached a minimum value at point of maximum TDN utilization, and then increased as illustrated in Figure 4, page 78. Least square means presented in Tables XV and XXIV, pages 48 and 66, respectively, indicated that 9.60 lb. of TDN was required to produce a pound of live weight at weaning compared to 8.49 lb. TDN at maximum TDN utilization. This difference was an improvement of 11.56 percent in TDN efficiency.

These results might be interpreted to indicate that marketing of young, light weight, weaned calves would not be an economical practice from a TDN efficiency standpoint in that the calves would not be heavy enough to alleviate the annual TDN intake charge of the cow.

The cow-calf producer could improve TDN efficiency by marketing the greatest number of heavy calves from a given amount of TDN intake which would help to reduce the annual TDN charge of the cows to a minimum. This might be accomplished by either managing the cow herd to calve early in the season or by utilizing the calves in a stocker program.

Although the weights, cumulative TDN intake and age of calves produced by cows of various weights and productive abilities varied, TDN efficiency values exhibited very little variation (S.D. = ± 0.6)

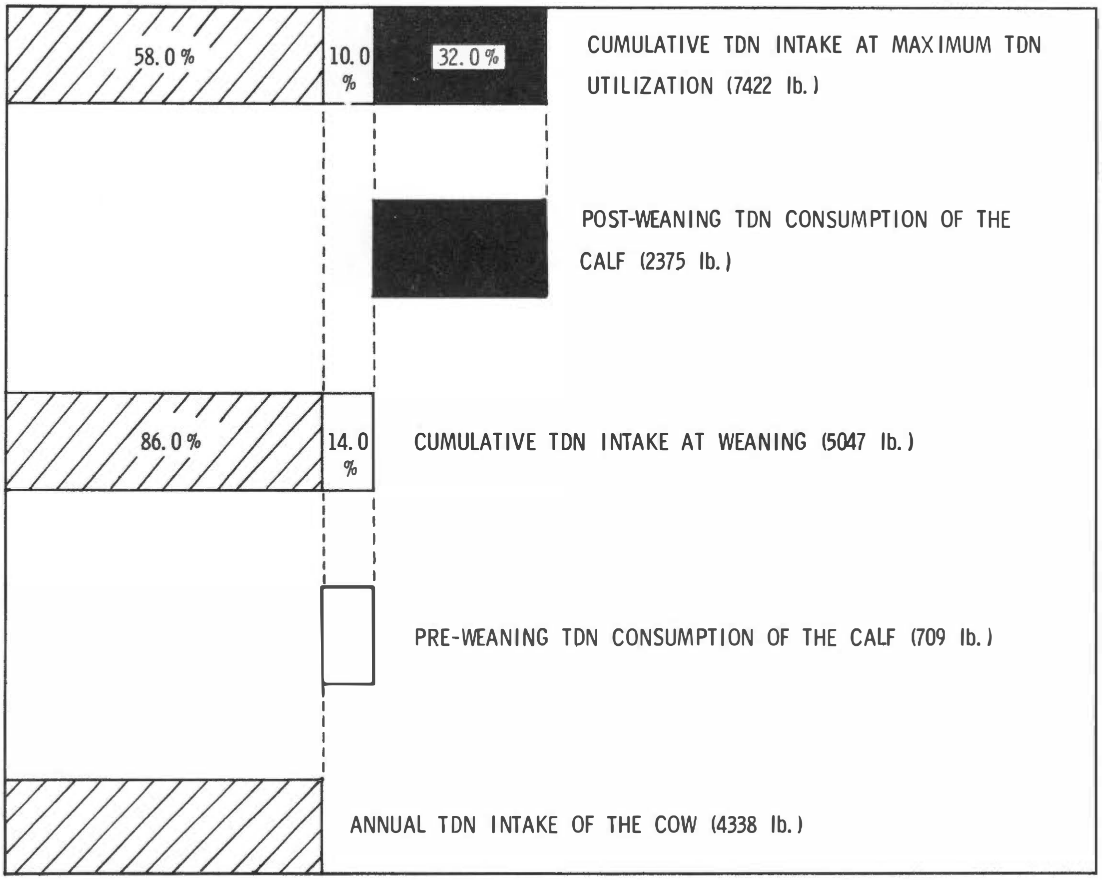

FIGURE 3

GRAPHIC REPRESENTATION OF THE COMPOSITION OF CUMULATIVE TDN INTAKE AT WEANING AND AT MAXIMUM TDN UTILIZATION

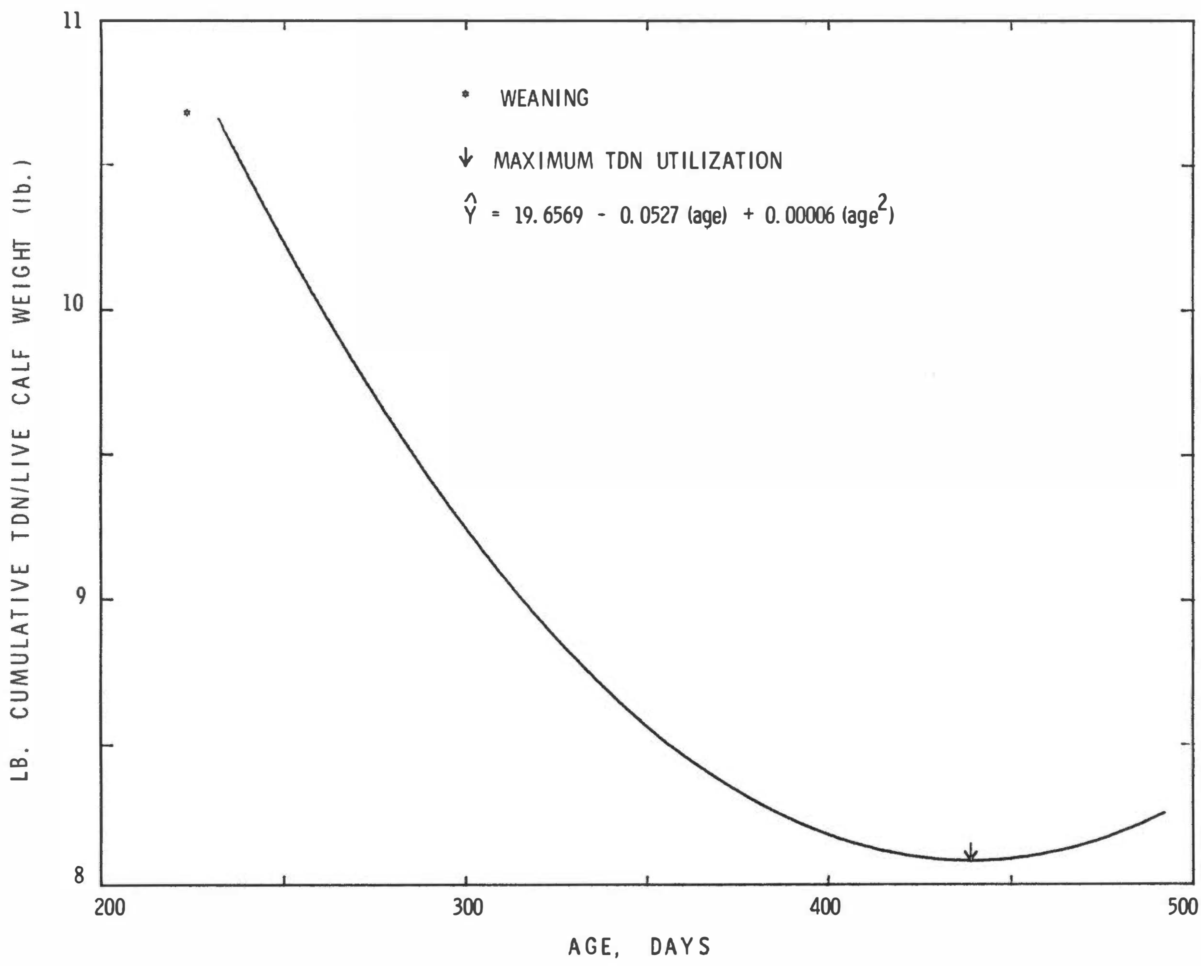

FIGURE 4

EFFICIENCY OF TDN UTILIZATION AT DIFFERENT AGES and was not significantly ($P < .05$) influenced by year or initial cow weight (Table XXIII, page 65).

Regression on initial cow weight accounted for 6.64 percent of variation in TDN efficiency at maximum TDN utilization compared to 11.91 percent at weaning. This might be interpreted to indicate that the influence of initial cow weight on TDN efficiency was reduced 44.24 percent from weaning to maximum TDN utilization (Figure 5). The reduction in influence of initial cow weight might be explained in that the influence of annual TDN intake of the cow composed a smaller percentage of the cumulative TDN intake at maximum TDN utilization (58.0 percent) than at weaning (86.0 percent), as shown in Figure 3, page 77.

Data illustrated in Figure 5 also contributed to the conclusion that lighter weight cows of the cow-calf pairs were slightly more efficient in conversion of consumed TDN into live calf weight at both weaning and at point of maximum TDN utilization.

Review of least square constants presented in Table XXIV, page 66, and data presented in Figures 6 and 7, pages 81 and 82, respectively, indicated that cows which produced bull calves were more efficient in converting ingested TDN into live weight than cows which produced either heifer or steer calves. Steers were slightly more efficient than the heifers, but less than bulls. The disadvantage in TDN efficiency of the heifers might be explained in that heifers matured at lighter weights than either bulls or steers which resulted in less weight that could be used to discount the cumulative TDN

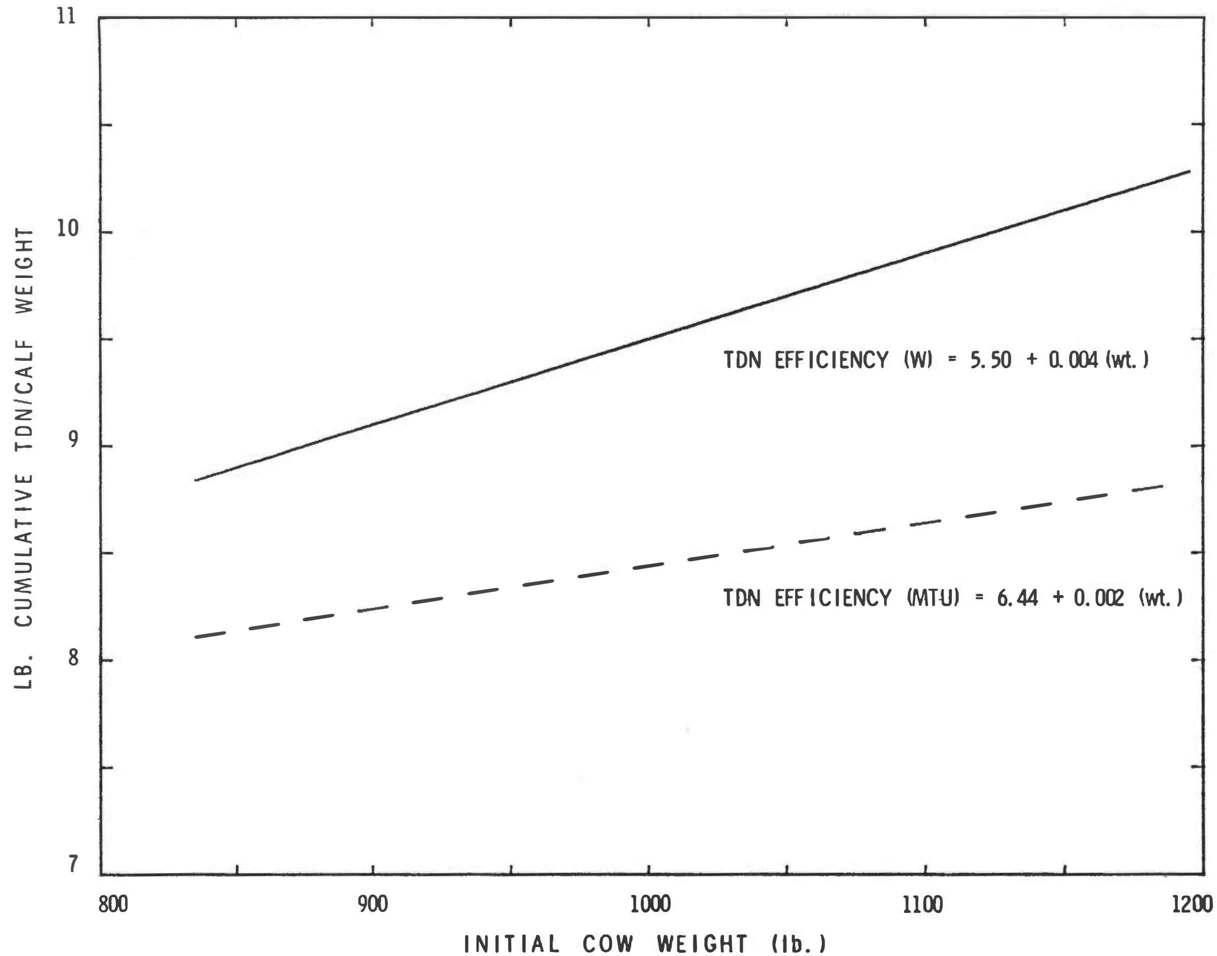

FIGURE 5

RELATIONSHIP BETWEEN INITIAL COW WEIGHT (Wt.) AND TDN EFFICIENCY AT WEANING (W) AND AT POINT OF MAXIMUM TDN UTILIZATION (MTU)[a]

[a]Regression equations were calculated from data in which the effects of year and sex were removed.

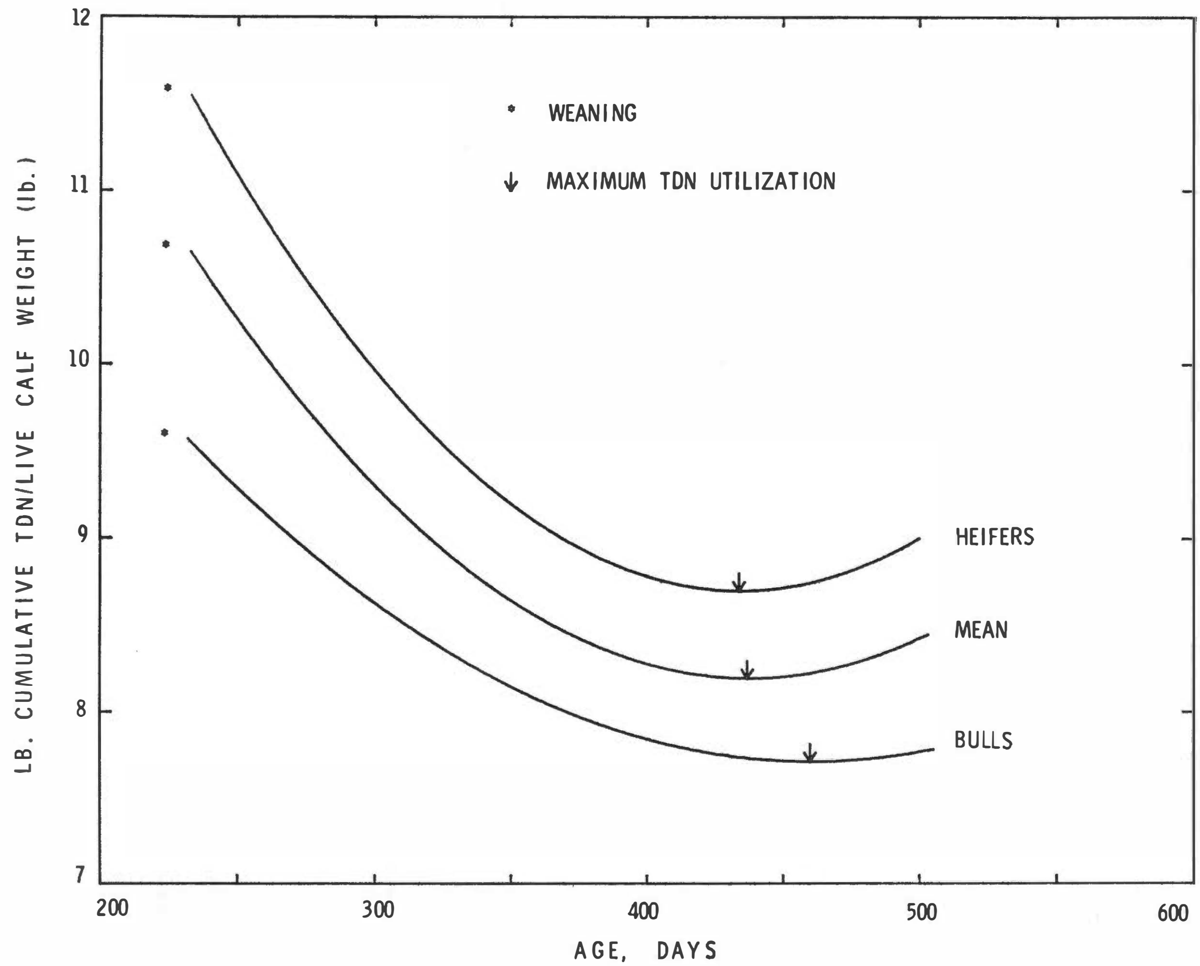

FIGURE 6

EFFICIENCY OF TDN UTILIZATION AT DIFFERENT AGES (1970)

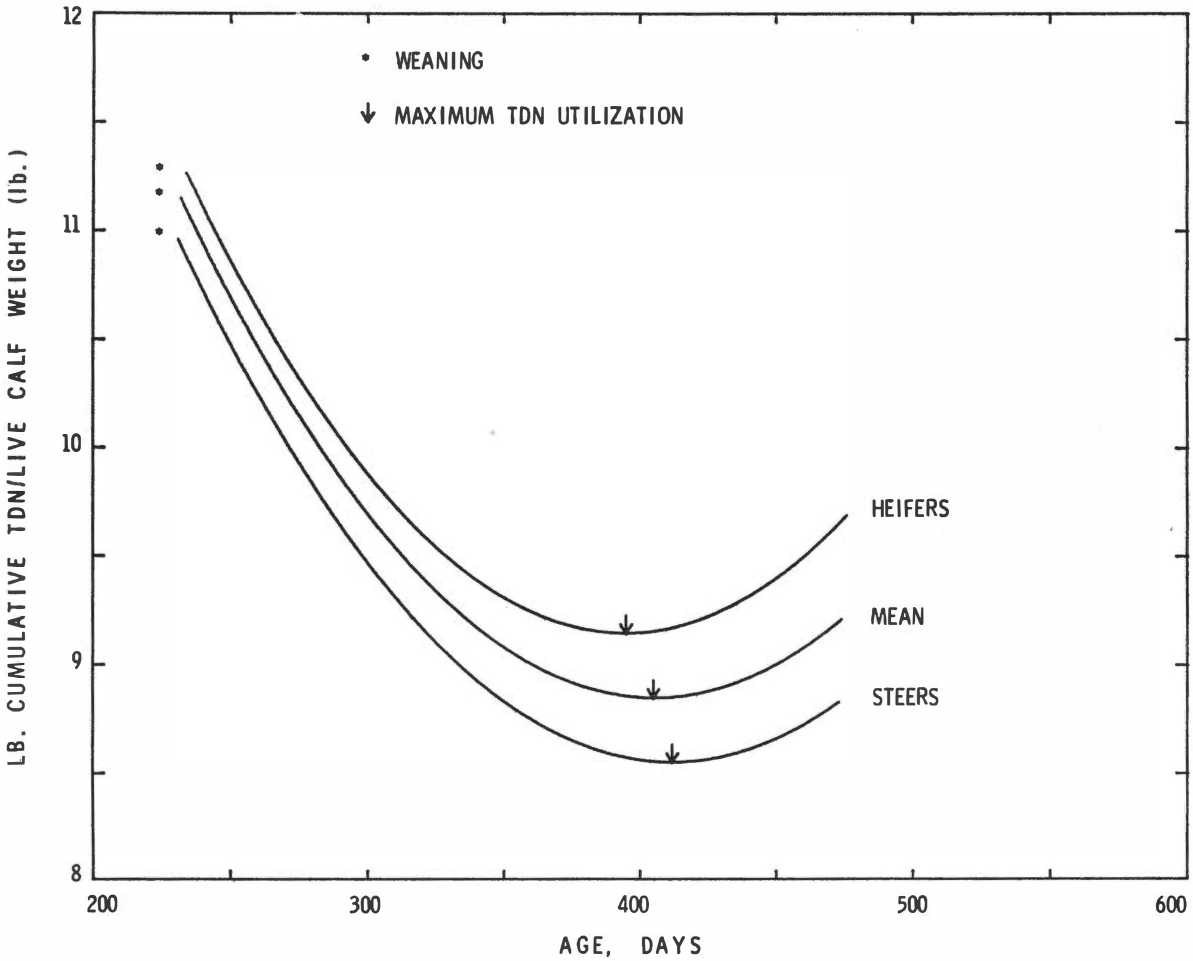

FIGURE 7

EFFICIENCY OF TDN UTILIZATION AT DIFFERENT AGES (1971) charge. These results might be interpreted to indicate that heifers could not compete with bulls or steers on a TDN efficiency basis. However, because of their early maturing characteristics, heifers might be more effectively utilized in a high forage feeding program.

Other maternal and calf traits thought to be biologically related to TDN efficiency and ability to significantly ($P<.05$) increase the variation explained above that accounted for by year, sex of calf and regression on cow weight were considered. Cow body depth (DB) was the only trait that met these qualifications. Regression on depth of body accounted for 19.87 percent of the variation in TDN efficiency and increased variation accounted for in TDN efficiency at maximum TDN utilization to 45.33 percent (Table XXX, Equation 2). The regression coefficient which resulted might be interpreted to indicate that deeper bodied cows of similar weights were not as efficient as shallow bodied cows in conversion of consumed TDN into live calf weight.

These results indicated that size (weight) of the dam and calf appeared to be of minor importance when cattle were fed to point of maximum TDN utilization. Washburn *et al.* (1948), Willey *et al.* (1951), Stonaker *et al.* (1952), Knox (1957), and Brumgardt (1971) reported similar results in that when cattle were fed to a similar degree of finish, no significant differences in feed costs and efficiency of gain were observed. Joandet and Cartwright (1971) reported little variation in TDN efficiency among different breeding groups; although weight and age at maximum TDN utilization varied.

TABLE XXX

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN TDN EFFICIENCY AT MAXIMUM TDN UTILIZATION[a]

Equation Number	TDN Efficiency Intercept	Regression Coefficients: Initial Cow Weight (lb.)	Regression Coefficients: DB (in.)	Variation Explained by Model (percent)
1	6.44	0.0018		32.10
2	1.80	- .0010	0.294**	45.33

[a]Calculated from least square equations of year, sex and regression on initial cow weight and depth of body. Year and sex were in all models and explained 25.46 percent of the variation in TDN efficiency.

**P<.01.

It was of interest in this study to compare TDN efficiency values and variation in TDN efficiency at point of maximum TDN utilization and a specific number of days on feed prior to and past the point of maximum TDN utilization. Means and standard deviation of TDN efficiency which occurred at one standard deviation above average days on feed post-weaning to reach maximum TDN utilization (241.4 days) and one standard deviation below average days on feed post-weaning to reach maximum TDN utilization (155.3) were compared with point of maximum TDN utilization (Table XXXI). These data implied that both inefficiencies and increased variation in TDN utilization occurred at days on feed earlier or later than at point of maximum TDN utilization. If the cattle were slaughtered at either the above times rather than at maximum TDN utilization, the TDN per lb. live weight values increased approximately 0.2 lb. For animals of 1,000 lb. slaughter weight, approximately 200 lb. more TDN would be required per animal if not slaughtered at point of maximum TDN utilization.

These data indicated that when TDN efficiency was compared at a similar end point (maximum TDN utilization) very little variation was observed. However, when compared prior to or past the point of maximum TDN utilization, variation in TDN efficiency increased. These results might provide some insight to the confusing reports concerning efficiency of cattle of various sizes. When comparing efficiency, it is extremely important to consider the end point when drawing conclusions. Literature previously cited (Washburn *et al.*, 1948; Willey *et al.*, 1951; Stonaker *et al.*, 1952; Knox, 1957; and Brumgardt,

TABLE XXXI

MEANS AND STANDARD DEVIATIONS OF WEIGHT, CUMULATIVE TDN, TDN EFFICIENCY AND AGE AT MAXIMUM TDN UTILIZATION, AND AT ONE STANDARD DEVIATION BELOW AND ABOVE AVERAGE NUMBER OF DAYS ON FEED TO REACH MAXIMUM TDN UTILIZATION[ab]

	Minus 1 S. D.		Maximum TDN Utilization		Plus 1 S. D.	
	$\bar{X}$	S. D.	$\bar{X}$	S. D.	$\bar{X}$	S. D.
Weight	810.2	89.5	884.1	100.4	960.2	97.5
Cumulative TDN (lb.)	6878.2	746.5	7423.9	931.4	8170.0	823.7
TDN Efficiency	8.55	0.72	8.31	0.62	8.58	0.68
Age (days)	387.8	20.2	428.7	34.6	473.9	20.2

[a]One standard deviation below average days on feed post-weaning to reach maximum TDN utilization = 155.3 days while one standard deviation above average days on feed = 241.4 days.

[b]Effects due to year and sex of calf were removed.

1971) indicated that when cattle were evaluated at a similar grade no significant difference in efficiency was reported. However, increased variation in efficiency might be expected when cattle were fed for the same time or to the same weight. On either of these bases, the larger, faster gaining cattle would be expected to require less feed due to less degree of maturity.

Coefficients of correlations among traits considered to have an influence on TDN efficiency at maximum TDN utilization are presented in Tables XXVI, XXVII, and XXIX, pages 70, 71 and 75, respectively. Cow traits considered were initial weight, MPPA, fat thickness, length of body, depth of body, height at withers, hook width, WT/HTW, annual TDN intake, and average daily milk production. Fat thickness, depth of body, WT/HTW and annual TDN intake of the cow were significantly ($P<.05$), positively related to TDN efficiency. Initial cow weight, length of body and hook width were positively related to TDN efficiency, but not significantly ($P<.05$) so. Results of these correlations revealed that as initial weight, initial fat thickness, depth of body, and WT/HTW of the cows increased, TDN efficiency became less desirable.

Coefficients of correlations presented in Tables XXVII and XXIX, pages 71 and 75, respectively, revealed very slight non-significant ($P>.05$) relationships between calf traits at maximum TDN utilization and TDN efficiency.

Results from this study might be interpreted to indicate that both the size of the dam and calf appeared to exhibit little influence on TDN efficiency. However, size might be of importance to the cattle industry if a specific carcass weight was demanded by the processor rather than a desired slaughter grade.

Age at Maximum TDN Utilization

Age at maximum TDN utilization averaged 428 days with a standard deviation of $\pm$31.5 days. Analysis of variance (Table XXIII, page 65) revealed that year and initial cow weight significantly ($P<.01$) influenced calf age at maximum TDN utilization. These effects might be attributed to the variation due to bulls utilized during 1970 and that larger cows produced calves which matured slower than calves from smaller cows. Regression of calf age at maximum TDN utilization on initial cow weight revealed that for each 100 lb. increase in cow weight, an increase of 15 days in age at point of maximum TDN utilization might be expected (Table XXXII).

Calves produced by fatter cows required a longer period of time to reach the point of maximum TDN utilization as evidenced by the positive regression coefficient of 2.40 presented in Table XXXII, Equation 2. The influence of initial fat might be confounded with weight or decreased milk production of fatter cows might have restricted the early nutrient intake of the calves which restricted growth, thereby increasing time to reach maturity and maximum TDN utilization.

Coefficients of correlations in Table XXVI, page 70, between cow weight, initial fat thickness and calf age at the point of maximum TDN utilization added support to the early conclusion that calves from

TABLE XXXII

INTERCEPTS, REGRESSION COEFFICIENTS AND VARIATION EXPLAINED IN AGE AT MAXIMUM TDN UTILIZATION[a]

		Regression Coefficients		
Equation Number	Age Intercept (days)	Initial Cow Weight (lb.)	Initial Cow F.T. (mm.)	Variation Explained by Model (percent)
1	275.11	0.15**		59.88
2	294.63	0.11*	2.40*	62.72

[a]Calculated from least square equations of year, sex of calf and regression of TDN efficiency at maximum TDN utilization on initial cow weight and fat thickness. Year and sex were in all models and explained 50.30 percent of the variation in TDN efficiency.

*P<.05.

**P<.01.

heavier, fatter cows were older at the point of maximum TDN utilization.

Coefficients of correlations between age at maximum TDN utilization, length of body, height at withers, height at hooks (Table XXVII, page 71) and the relationship between weight and age at maximum TDN utilization (Table XXIX, page 75) indicated that longer bodied, taller and heavier calves were also the older ones at the point of maximum TDN utilization.

It might be concluded that variation in age at maximum TDN utilization might be attributed to differences in rate of maturity.

CHAPTER V

SUMMARY

Data utilized in this study were from records (collected over a two-year period) of 45 Angus cow-calf pairs in which both the individual TDN consumption of the cows over a twelve-month period and the individual TDN consumption of the calves from birth to slaughter (excluding TDN provided by milk) were recorded. The objectives of this study were to determine total digestible nutrient (TDN) consumed by cows of various sizes and weights, to determine the TDN intake of both cow and calf per unit weight of slaughter calves which varied in growth potential, to establish weights at which maximum TDN utilization occurred, and to establish relationships among characteristics of cows and calves, and overall TDN efficiency and TDN efficiencies for various periods.

Cows were selected at weaning, confined to individual pens and individually fed to the following weaning. Cows selected ranged in weight from 835 lb. to 1,195 lb. In addition to initial weight, skeletal measurements and subcutaneous fat deposition between the twelfth and thirteenth ribs were recorded at the initiation of each trial. Milk production of the cows were made at 28-day intervals.

Data collected on the calves were weights recorded at birth and at 28-day intervals during the preweaning period and at 14-day intervals during the post-weaning period. Ultrasonic measurements of subcutaneous fat thickness were recorded at weaning and at each weighing during the post-weaning period. Skeletal body measurements of the calves were recorded at approximately 120-days of age, at weaning, and at slaughter.

Cows were fed a grass silage ration of 20 percent TDN supplemented with dehydrated alfalfa pellets to insure adequate energy and dry matter intake. The cows were fed to maintain condition and weight during the nonlactation or wintering period and were fed *ad libitum* during the lactation period in an attempt to simulate pasture condition.

During lactation, the calves ran with the cows and were provided a creep feed of alfalfa pellets in an attempt to simulate feed intake under pasture conditions. Following weaning, the calves were individually fed a 60 percent TDN ration to slaughter.

The total amount of cumulative TDN consumed by each cow-calf pair at a given progeny age was determined by combining the TDN consumed by the cow during both the nonlactation and lactation periods and adding the amount of TDN consumed by the calf from birth to slaughter in addition to the TDN provided by the milk.

Efficiency of TDN utilization for a cow-calf pair was calculated as the ratio of cumulative TDN to live weight at that particular age. The point at which the ratio of cumulative TDN intake to live calf weight was minimum was referred to as the point of maximum TDN utilization.

Cows utilized in this study averaged 1,020 lb. (S.D. = 99.0 lb.) in initial weight. Weight and linear measurements of the cows were significantly ($P<.05$) positively related. However, small, nonsignificant ($P>.05$) relationships were observed between MPPA, weight and initial cow body measurements.

Annual TDN intake of the cows averaged 4,338 (S.D. = $\pm$459 lb.). Initial cow weight exhibited a significant ($P<.01$) linear effect on annual TDN intake in that annual TDN intake increased 314 lb. as initial cow weight increased 100 lb. Neither MPPA nor average daily milk production was significantly ($P<.05$) related to annual TDN intake.

Daily milk production was positively, but nonsignificantly ($P>.05$), influenced by initial cow weight and linear dimensions. Sex of calf did not influence milk production.

Initial cow weight did not have a significant ($P<.05$) effect on either calf birth weight or weaning weight. However, the trend was for heavier cows to produce heavier calves at both birth and weaning. Birth weight increased 3.3 lb. and weaning weight 6.9 lb. for each 100 lb. increase in cow weight. Hook width was the only cow trait to exhibit a significant ($P<.05$) positive relationship to calf birth weight. Initial fat thickness of the cows exhibited a significant ($P<.05$) influence on weaning weight. Heifers were lighter at weaning than either steer or bull calves. Calves heavier at weaning were also deeper and longer bodied and taller at both the withers and hooks.

Initial cow weight had a significant ($P<.01$) linear effect on calf weight at maximum TDN utilization. Calf weight increased 33.5 lb. for each 100 lb. increase in cow weight. Total milk production of the cows and calf age exhibited a significant ($P<.05$) influence on calf weight at point of maximum TDN utilization, and post-weaning TDN consumption of the calves exhibited a highly significant ($P < .01$) influence. Calves heavier at maximum TDN utilization were also deeper and longer bodied and taller.

Cumulative TDN intake averaged 5,049 lb. (S.D. = $\pm$504 lb.) at weaning and 7,422 lb. (S.D. = $\pm$815 lb.) at maximum TDN utilization and was significantly ($P < .01$) influenced by initial cow weight. An increase of 100 lb. in initial cow weight resulted in 289 lb. and 464 lb. increase in cumulative TDN at weaning and maximum TDN utilization, respectively. Eighty-six percent of the cumulative TDN intake at weaning and 58.0 percent at maximum TDN utilization was composed of the annual TDN intake of the cow. Calves which were heavier, older and larger in body dimensions required increased amounts of cumulative TDN to reach maximum TDN utilization. It was concluded that both cumulative TDN intake at weaning and point of maximum TDN utilization were a function of size of both the dam and progeny.

Calves produced by heavier and fatter cows and calves which were heavier, taller and longer bodied required a longer period of time to reach maximum TDN utilization. Calf age at maximum TDN utilization increased 15 days for each 100 lb. increase in initial cow weight.

TDN efficiency was determined as the ratio of cumulative TDN intake to live calf weight. TDN efficiency at weaning averaged 9.60 (S.D. = $\pm$1.12) and was significantly ($P < .01$) influenced by initial cow weight. TDN efficiency increased 0.4 for each 100 lb. increase in initial cow weight.

Although weight, cumulative TDN intake, and age of calves at point of maximum TDN utilization differed, TDN efficiency averaged 8.49, exhibited very little variation (S.D. = ± 0.6) and was not significantly ($P < .05$) influenced by either initial cow weight or any calf trait. However, when evaluated either prior to or past maximum TDN utilization, both the values and variation in TDN efficiency increased.

These results indicated that TDN efficiency at weaning was primarily a function of size of both the dam and progeny while at point of maximum TDN utilization, size of the dam and progeny exhibited very little influence on TDN efficiency.

LITERATURE CITED

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A.O.A.C. 1965. Official Methods of Analysis (10th ed.). Association of Official Agricultural Chemists. Washington, D.C.

Blackmore, D. W., L. O. McGilland and J. L. Lush. 1958. Relationships between body measurements, meat conformation, and milk production. J. Dairy Sci. 41:1050.

Brinks, J. S., R. T. Clark, N. M. Kleifer and J. R. Queensberry. 1962. Mature weight in Hereford range cows--heritability, repeatability, and relationship to calf performance. J. Animal Sci. 21:501.

Brown, C. J. and J. E. Brown. 1971. Influence of development pattern on growth and maintenance costs of beef cows. Ark. Farm Res. 20.

Brungardt, V. H. 1971. Efficiency and profit differences of Angus, Charolais and Hereford cattle varying in size and growth. University of Wisconsin, Madison.

Carpenter, J. A., Jr., H. A. Fitzhugh, Jr. and J. E. Brown. 1971. Growth curve parameters and productivity of beef cows. J. Animal Sci. 32:374.

Dawson, W. M., R. W. Phillips and W. H. Black. 1947. Birth weight as a criterion of selection in beef cattle. J. Animal Sci. 24:188.

Drewry, K. J., C. J. Brown and R. S. Honea. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Animal Sci. 18:939.

Eckles, C. H., T. W. Gullickson and W. M. Neal. 1927. Maintenance requirements for calves tested by live weight methods. J. Dairy Sci. 10:431.

Ewing, S. A., Larry Smithson, Craig Ludwig and Dwight Stephens. 1967. Influence of mature cow size on feed and energy requirements. Okla. Agr. Exp. Sta. Misc. Publ. MP-79:73.

Ewing, S. A., Larry Smithson, Craig Ludwig and Dwight Stephens. 1968. Energy requirements of mature beef cows as influenced by weight and level of milk production. Okla. Agr. Exp. Sta. Misc. Publ. MP--80:56.

Fitzhugh, H. A., Jr., T. C. Cartwright and R. S. Temple. 1967. Preweaning gains of beef calves with special reference to the effect of weight of dam. Tex. Agr. Exp. Sta. Prog. Rpt. PR--2486.

Fitzhugh, H. A., Jr., and St. C. S. Taylor. 1971. Genetic analysis of maturity. J. Animal Sci. 33:717.

Garrett, W. N., J. H. Meyer and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Animal Sci. 18:528.

Gillooly, J. E., L. L. Wilson, C. E. Thompson, M. C. Rugh, T. A. Long, and H. R. Purdy. 1967. Effects of energy level and cow size on milk yield and calf gain. J. Animal Sci. 26:1486. (Abstr.).

Graham, N. McC. 1967. The metabolic rate of fasting sheep in relation to total and lean body weight, and the estimation of maintenance requirements. Australian J. Agr. Res. 18:127.

Gregory, K. E., C. T. Blunn, and M. L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. J. Animal Sci. 9:338.

Guilbert, H. W. and P. W. Gregory. 1944. Feed utilization tests with cattle. J. Animal Sci. 3:143.

Harvey, W. R. 1960. Least squares analysis of data with unequal subclass numbers. U.S.D.A. Agr. Res. Ser. Bul. ARS--20:8.

Hawkins, D. R., C. F. Parker, E. W. Klosterman and W. R. Harvey. 1965. Body weight as a measure of productivity of Hereford cows. J. Animal Sci. 24:848. (Abstr.).

Heaney, D. P., and W. J. Pigden. 1963. Interrelationships and conversion factors between expressions of the digestibility energy value of forages. J. Animal Sci. 22:956.

Joandet, G. E. and T. C. Cartwright. 1971. Estimation of efficiency of beef production. J. Animal Sci. 29:862.

Klosterman, E. W., V. R. Cahill and C. F. Parker. 1968. A comparison of the Hereford and Charalois breeds and their crosses under two systems of management. Ohio Agr. Res. Bul. 1011.

Klosterman, E. W., L. G. Sanford and C. F. Parker. 1968. Effect of cow size and condition and ration protein content upon maintenance requirements of mature beef cows. J. Animal Sci. 27:242.

Knapp, Bradford, Jr., A. L. Baker, J. R. Queensberry and R. T. Clark. 1942. Growth and production factors in range cattle. Mont. Agr. Exp. Sta. Bul. 400.

Knapp, Bradford, Jr., W. V. Lambert and W. H. Black. 1940. Factors influencing length of gestation and birth weight in cattle. J. Agr. Res. 61:277.

Knott, J. C., R. E. Hodgson and E. W. Ellington. 1934. Methods of measuring pasture yield with dairy cattle. Wash. Agr. Exp. Sta. Bul. 295.

Knox, J. H. 1957. The interrelations of type, performance and carcass characteristics. J. Animal Sci. 16:240.

Kress, D. D., E. R. Hauser and A. B. Chapman. 1969. Efficiency of production and cow size in beef cattle. J. Animal Sci. 29:373.

Lambourne, L. J. and T. F. Reardon. 1963. Effects of environment on the maintenance requirements of merino wethers. Australian J. Agr. Res. 14:272.

Lindholm, H. B. and H. H. Stonaker. 1957. Economic importance of traits and selection indexes for beef cattle. J. Animal Sci. 16:998.

Marchello, J. A., D. W. Blackmore and J. J. Urick. 1960. Heritabilities of 18 month weight of heifers and the relationship of this weight to the birth and weaning weight of the heifer's first calf. Proc. West. Sect. Amer. Soc. of Animal Prod. 11:x.

Marlowe, T. J. 1962. Relation of mature weight and grade of parent to preweaning performance of beef calves. J. Animal Sci. 21:974. (Abstr.).

Marlowe, T. J. and H. A. Stewart. 1955. A comparison of Africander Brahman and Hereford bulls on grade Hereford cows. Proc. Assoc. Sou. Agr. Workers. p. 82.

McCandlish, A. C. and W. G. Gaessler. 1920. Influence of condition on the maintenance requirements of dairy cattle. Iowa Agr. Exp. Sta. Bul. 60. p. 403.

Meiske, J. C., G. D. Enfield and A. L. Harvey. 1964. Effect of cow weight and other factors on performance of beef calves. J. Animal Sci. 23:1197. (Abstr.).

Melton, A. A. 1968. Heifer size--dam size--importance in beef production. Tex. Agr. Progress 14:8.

Melton, A. A., T. C. Cartwright and W. E. Kruse. 1967. Cow size as related to efficiency of beef production. Tex. Agr. Exp. Sta. Prog. Rpt. PR 2485.

Melton, A. A., J. K. Riggs, L. A. Nelson and T. C. Cartwright. 1967. Milk production, composition and calf gains of Angus, Charolais and Hereford cows. J. Animal Sci. 26:804.

N.R.C. 1970. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. National Research Council, Washington, D.C.

Neel, J. B. 1966. The effect of initial winter condition and level of winter feeding on beef cow and calf performance. M. S. Thesis. University of Tennessee, Knoxville.

Neville, W. E. 1962. Influence of dam's milk production and other factors on 120- and 240-day weight of Hereford calves. J. Animal Sci. 21:315.

Neville, W. E., Jr. and M. E. McCullough. 1969. Calculated energy requirements of lactating and non-lactating Hereford cows. J. Animal Sci. 29:823.

O'Mary, C. C., T. L. Brown and M. E. Ensminger. 1959. Correlation of cow measurements to 180 day adjusted weaning weights of these calves. J. Animal Sci. 18:1471. (Abstr.).

Petty, R. R., Jr., C. C. Boykin, Jr. and B. R. Eddleman. 1965. Estimated costs of maintaining a beef cow in Texas. Tex. Agr. Exp. Sta. PR--2370.

Pinney, D. O., L. S. Pope, Dwight Stephens and L. M. Henderson. 1962. Lifetime performance of beef cows wintered each year on three different levels. Okla. Agr. Exp. Sta. Misc. Publ. MP--67:63.

Pope, L. S., L. Smithson, D. F. Stephens, D. O. Pinney and M. Velasseo. 1963. Factors affecting milk production of range beef cows. Okla. Agr. Exp. Sta. Misc. Publ. 70:69.

Prater, T. E. 1970. Costs and returns of cow-calf operations. Tex. Agr. Ext. Serv. MP--947.

Rebhan, H. J. and J. O. Donker. 1960. Effect of condition of the animal on the requirement of energy for maintenance of the bovine. J. Dairy Sci. 43:1282.

Sawyer, W. A., R. Bogart, J. D. Wallace, R. J. Raleigh, J. S. Brinks and R. T. Clark. 1963. Relationship among weights of dam and progeny performance. J. Animal Sci. 22:822. (Abstr.).

Simpson, M. J., L. L. Wilson, J. H. Ziegler, L. G. Bair and H. Varela-Alvaref. 1972. Relationships of cow weight, measures and scores with progeny characteristics in an Angus-Holstein Herd. J. Animal Sci. 34:185.

Smithson, Larry. 1968. Energy requirements of mature beef cows as influenced by body size. Ph. D. Dissertation, Oklahoma State University, Stillwater.

Stonaker, H. H., M. H. Hazaleus and S. S. Wheeler. 1952. Feedlot and carcass characteristics of individually fed compress and conventional type Hereford steers. J. Animal Sci. 11:17.

Stonaker, H. H., J. E. Ingalls and S. S. Wheeler. 1952. Winter hay consumption of breeding females of large, intermediate and compress types of Hereford cattle. J. Animal Sci. 11:26.

Tanner, J. E., R. J. Cooper and W. E. Kruse. 1965. Relationships between weaning weights of calves and weights and measurements of their dams. Tex. Agr. Exp. Sta. Prog. Rpt. PR 2369.

Taylor, St. C. S. and H. A. Fitzhugh, Jr. 1971. Genetic relationships between mature weight and time taken to mature within a breed. J. Animal Sci. 33:726.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassland Soc. 18:104.

Totusek, Robert and Dudley Arnett. 1965. Estimation of milk production in beef cows. J. Animal Sci. 24:906. (Abstr.).

Totusek, Robert, G. L. Holland, E. W. Jones and W. D. Campbell. 1969. The influence of excessive fatness on the performance of beef females. Okla. Agr. Exp. Sta. MP--57:40.

Touchberry, R. W. 1951. Genetic correlations between five body measurements, weight, type and production in the same individual among Holstein cows. J. Dairy Sci. 34:242.

Trowbridge, P. F., C. R. Moulton and L. D. Haigh. 1915. The cost of maintenance of cattle as influenced by condition, previous plane of nutrition, age, season of the year, length of time on maintenance, type, and size of animal. Mo. Agr. Exp. Sta. Res. Bul. 18.

Urick, J. J., B. W. Knapp, J. S. Brinks, O. F. Pahnish and T. M. Riley. 1971. Relationships between cow weights and calf weaning weights in Angus, Charolais and Hereford breeds. J. Animal Sci. 33:343.

Vaccaro, R. and E. U. Dillard. 1966. Relationship of dam's weight and weight changes to calf's growth rate in Hereford cattle. J. Animal Sci. 25:1063.

Washburn, L. E., J. Matsushima, H. E. Pearson and R. C. Tom. 1948. Nutrient utilization by compact and conventional type shorthorn steers. J. Animal Sci. 7:127.

Willey, N. B., O. D. Butler, J. K. Riggs, J. H. Jones and P. J. Lyerly. 1951. The influence of type on feedlot performance and killing qualities of Hereford steers. J. Animal Sci. 10:195.

Wilson, L. L., J. E. Gillooly, M. C. Rugh, C. E. Thompson and H. R. Purdy. 1969. Effects of energy intake, cow body size and calf sex on composition and yield of milk by Angus-Holstein cows and preweaning growth rate of progeny. J. Animal Sci. 28:789.

Winchester, C. F. and W. A. Hendricks. 1953. Energy requirements of beef calves for maintenance and growth. U.S.D.A. Tech. Bul. 1071.

Wistrand, G. C. and J. K. Riggs. 1966. Milk production of Santa Gertudis cows as measured by calf nursing and machine milking methods. J. Animal Sci. 24:263. (Abstr.).

Woodward, R. R., R. T. Clark and J. H. Cummings. 1942. Studies on large and small type Hereford cattle. Mont. Agr. Exp. Sta. Bul. 401.

Zimmerman, J. E., L. S. Pope and Dwight Stephens. 1958. Effect of different levels of winter supplement and age at first upon the performance of beef cows and replacement heifers. Okla. Agr. Exp. Sta. Misc. Publ. MP--51:59.

APPENDIX

TABLE XXXIII

COEFFICIENTS OF CORRELATIONS BETWEEN INITIAL COW BODY TRAITS AND CALF LINEAR DIMENSIONS AT WEANING[ab]

	Calf Linear Dimensions at Weaning			
Cow Traits	Depth of Body	Length of Body	Height at Withers	Height at Hooks
Initial Weight	0.060	- .078	- .011	0.054
MPPA	0.347*	0.189	0.245	0.093
FT	- .301*	- .247	- .164	- .108
LB	0.257	0.103	0.259	0.290
DB	0.088	- .003	0.169	0.229
HTW	0.189	0.007	0.209	0.167
HKW	0.190	0.069	0.192	0.257
WT/HTW	0.046	- .132	- .105	- .032

[a]Calf linear dimensions were adjusted to 270 days of weaning age in 1970 and 253 days of weaning age in 1971.

[b]Correlations were calculated from data in which the effects of year and sex were removed.

*$P < .05$.

**$P < .01$.

TABLE XXXIV

COEFFICIENTS OF CORRELATIONS BETWEEN CALF TRAITS AT WEANING AND AT POINT OF MAXIMUM TDN UTILIZATION[ab]

Traits at Maximum TDN Utilization	Traits at Weaning				
	Weight	ADG	FT	Cumulative TDN	TDN Efficiency
Weight	0.530**	0.489**	0.354*	0.546**	0.029
ADG	0.795**	0.828**	0.161	0.409**	- .320*
FT	0.120	0.133	0.377*	0.239	0.123
Cumulative TDN	0.382*	0.363*	0.370*	0.810*	0.443**
TDN Efficiency	- .036	- .188	0.044	0.332*	0.334*
Age	- .325*	- .338*	0.236	0.271	0.550**

[a]Correlations were calculated from data in which the effects of year and sex were removed.

[b]Traits at weaning were adjusted to 270 days of age in 1970 and 253 days of age in 1971.

*$P < .05$.

**$P < .01$.

TABLE XXXV

COEFFICIENTS OF CORRELATIONS BETWEEN INITIAL COW TRAITS AND CALF LINEAR MEASUREMENTS AT POINT OF MAXIMUM TDN UTILIZATION[a]

Initial Cow Traits	Calf Linear Dimensions			
	Depth of Body (in.)	Length of Body (in.)	Height at Withers (in.)	Height at Hooks (in.)
Weight (lb.)	0.424**	0.156	0.227	0.153
MPPA (lb./day)	0.214	0.026	- .055	- .080
FT (mm.)	0.062	- .006	0.106	0.035
LB (in.)	0.435**	0.216	0.279	0.175
DB (in.)	0.336*	0.169	0.265	0.300
HTW (in.)	0.340*	0.086	0.233	0.152
HKW (in.)	0.307*	0.251	0.215	0.240
WT/HTW (lb./in.)	0.343*	0.088	0.131	0.084

[a]Correlations were calculated from data in which the effects of year and sex were removed.

*$P < .05$.

**$P < .01$.

TABLE XXXVI

OBSERVED VALUES OF ANNUAL TDN INTAKE AND AVERAGE DAILY MILK PRODUCTION OF COWS OF VARIOUS WEIGHTS AND PRODUCTIVE ABILITY (1969-70)

Initial Weight (lb.)	MPPA (lb./day)	Annual TDN Intake (lb.)	Average Daily Milk Production (lb.)
1195	1.98	4949	18.0
1180	1.87	4573	14.5
1140	2.01	4528	15.4
1115	1.93	3824	16.0
1115	1.67	4568	13.6
1115	1.63	4447	14.2
1095	1.85	4859	15.6
1070	2.01	4413	16.8
1055	1.99	4105	14.3
1030	2.05	4404	14.5
1030	1.81	4260	16.8
1020	1.98	4465	14.0
1015	1.94	4480	15.7
1015	1.93	4145	14.2
995	2.09	4397	15.1
990	1.95	4235	15.1
985	2.02	4049	15.4
970	1.97	4200	10.9
970	1.99	4055	15.0
920	1.67	3079	15.5
920	1.83	4040	13.4
890	1.83	3418	11.9
875	1.90	3803	12.1

TABLE XXXVII

OBSERVED VALUES OF ANNUAL TDN INTAKE AND AVERAGE DAILY MILK PRODUCTION OF COWS OF VARIOUS WEIGHTS AND PRODUCTIVE ABILITY (1970-71)

Initial Weight (lb.)	MPPA (lb./day)	Annual TDN Intake (lb.)	Average Daily Milk Production (lb.)
1195	1.98	4488	15.1
1180	1.87	4451	11.6
1140	2.01	5381	12.0
1115	1.67	4292	12.2
1115	1.63	5430	14.2
1095	1.85	4823	15.7
1070	1.66	5582	14.9
1070	2.01	4929	17.6
1055	1.99	3574	13.8
1030	2.05	4414	13.6
1030	1.81	4953	14.8
1015	1.88	4635	15.9
985	2.02	4492	12.7
975	1.69	3794	15.6
970	1.76	4692	14.7
940	1.88	4674	14.0
920	1.67	3051	13.3
920	1.83	4177	11.3
890	1.83	3521	13.0
875	1.90	3750	13.0
825	1.90	4412	16.3
810	1.81	4287	12.7

TABLE XXXVIII

OBSERVED VALUES OF TRAITS AT BIRTH AND WEANING (1969-70)

Cow Traits				Weaning		
Initial Weight (lb.)	MPPA (lb./day)	Sex[a]	Birth Weight (lb.)	Weight (lb.)	Cumulative TDN Intake (lb.)	TDN Efficiency
1195	1.98	2	65	500	5284	10.6
1180	1.87	1	65	390	5016	12.9
1140	2.01	1	65	420	5020	12.0
1115	1.93	2	55	490	4451	9.1
1115	1.67	2	70	365	4782	13.1
1115	1.63	1	70	580	4936	8.5
1095	1.85	1	85	530	5294	10.0
1070	2.01	2	75	500	4809	9.6
1055	1.99	2	45	405	4351	10.7
1030	2.05	1	60	465	4773	10.3
1030	1.81	1	55	565	4765	8.4
1020	1.98	1	45	435	4774	11.0
1015	1.94	2	70	510	4808	9.4
1015	1.93	1	85	450	4502	10.0
995	2.09	2	65	470	4755	10.1
990	1.95	1	85	440	4489	10.2
985	2.02	2	60	400	4417	11.0
970	1.97	2	75	315	4454	13.7
920	1.99	1	45	410	4288	10.4
920	1.67	1	75	485	3257	7.3
920	1.83	2	65	420	4431	10.6
890	1.83	1	50	405	3731	9.2
875	1.90	2	70	385	4087	10.6

[a]1 = Male, 2 = Female.

TABLE XXXIX

OBSERVED VALUES OF TRAITS AT BIRTH AND WEANING (1970-71)

Cow Traits				Weaning		
Initial Weight (lb.)	MPPA (lb./day)	Sex[a]	Birth Weight (lb.)	Weight (lb.)	Cumulative TDN Intake (lb.)	TDN Efficiency
1195	1.98	3	65	390	4305	11.0
1180	1.87	3	60	365	4700	12.9
1140	2.01	3	70	490	6007	12.2
1115	1.67	2	65	385	4606	12.0
1115	1.63	2	60	400	5838	14.6
1095	1.85	3	75	455	5162	11.3
1070	1.66	3	70	525	6089	11.6
1055	2.01	3	80	555	5453	9.8
1055	1.99	2	50	435	4060	9.3
1030	2.05	2	60	405	4862	12.0
1030	1.81	3	75	510	5401	10.6
1015	1.88	2	65	485	5192	10.7
985	2.02	3	50	465	4925	10.6
975	1.69	3	55	435	5388	12.4
970	1.76	2	55	420	4926	11.7
940	1.88	3	55	345	4895	14.2
920	1.67	3	55	315	3200	10.2
920	1.83	3	75	340	4293	12.6
890	1.83	3	75	360	3841	10.7
875	1.90	2	35	325	4018	12.4
825	1.90	3	55	410	4332	10.6
810	1.81	2	50	415	4280	10.3

[a]2 = Female, 3 = Steer.

TABLE XL

OBSERVED VALUES OF TRAITS AT MAXIMUM TDN UTILIZATION (1969-70)

Cow Traits			Traits at Maximum TDN Utilization			
Initial Weight (lb.)	MPPA (lb./day)	Sex[a]	Weight (lb.)	Cumulative TDN Intake (lb.)	TDN Efficiency	Age (days)
1195	1.98	2	1105	9546	8.7	500
1180	1.87	1	1108	8583	7.7	545
1140	2.01	1	783	7604	9.4	508
1115	1.93	2	995	8016	8.0	515
1115	1.67	2	790	5989	9.5	458
1115	1.63	1	908	8538	9.5	492
1095	1.85	1	1016	8169	8.0	408
1070	2.01	2	1007	8751	8.4	512
1055	1.99	2	877	7716	8.8	481
1030	2.05	1	1060	8343	7.8	510
1030	1.81	1	1057	7558	7.1	434
1020	1.98	1	1003	8388	8.3	416
1015	1.94	2	958	8284	8.6	483
1015	1.93	1	1077	8175	7.5	425
995	2.09	2	991	8585	8.7	490
990	1.95	1	1027	7852	7.6	408
985	2.02	2	715	6185	7.5	436
970	1.97	2	786	7349	8.4	460
920	1.99	1	917	6988	7.4	435
920	1.67	1	969	6217	6.4	409
920	1.83	2	908	8044	8.8	472
890	1.83	1	905	6576	7.2	420
875	1.90	2	828	6882	8.3	411

[a]1 = Male, 2 = Female.

TABLE XLI

OBSERVED VALUES OF TRAITS AT MAXIMUM TDN UTILIZATION (1970-71)

Cow Traits			Traits at Maximum TDN Utilization			
Initial Weight (lb.)	MPPA (lb./day)	Sex[a]	Weight (lb.)	Cumulative TDN Intake (lb.)	TDN Efficiency	Age (days)
1195	1.98	3	837	6772	8.0	370
1180	1.87	3	772	7179	9.2	390
1140	2.01	3	976	8773	8.9	440
1115	1.67	2	833	7494	8.9	429
1115	1.63	2	760	8294	8.4	434
1095	1.85	3	843	7556	8.9	400
1070	1.66	3	1035	8920	8.5	429
1055	2.01	3	968	7571	7.8	398
1055	1.99	2	631	5472	8.7	349
1030	2.05	2	710	6672	9.3	392
1030	1.81	3	870	7528	8.6	396
1015	1.88	2	838	7377	8.7	398
985	2.02	3	862	6987	8.0	421
975	1.69	3	871	7836	8.9	400
970	1.76	2	744	6894	9.2	384
940	1.88	3	709	6934	8.3	384
920	1.67	3	668	5354	7.9	357
920	1.83	3	802	6608	8.1	383
890	1.83	3	744	6241	8.3	432
875	1.90	2	687	6050	8.7	371
825	1.90	3	777	6564	9.6	392
810	1.81	2	806	6804	8.4	410

[a]2 = Female, 3 = Steer.

VITA

James Burkett Neel, eldest son of James Davidson Neel and Florence Burkett Neel, was born at Columbia, Tennessee, on April 11, 1940. He was reared on the family farm in Tullahoma, Tennessee. He graduated from Manchester Central High School in May, 1958. He received the Bachelor of Science degree in Agriculture from Middle Tennessee State University, Murfreesboro, in June, 1964, and the Master of Science degree in Animal Husbandry from the University of Tennessee, Knoxville, in August, 1966. He was married to the former Elsie Lucille O'Daniell on August 6, 1966. He was employed as an Assistant Agricultural Extension Agent in Madison County, Jackson, Tennessee, from August, 1966, to August, 1968, a position from which he resigned to pursue graduate study at the University of Tennessee. He received the Doctor of Philosophy degree from the University of Tennessee in March, 1973. His area of study was Animal Science with minors in Agricultural Economics and Agricultural Extension.